SCIENTIFIC AMERICAN SUPPLEMENT. No 1091

Scientific American, established 1845.
Scientific American Supplement, Vol. XLII, No. 1091.

NEW YORK, NOVEMBER 28, 1896.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

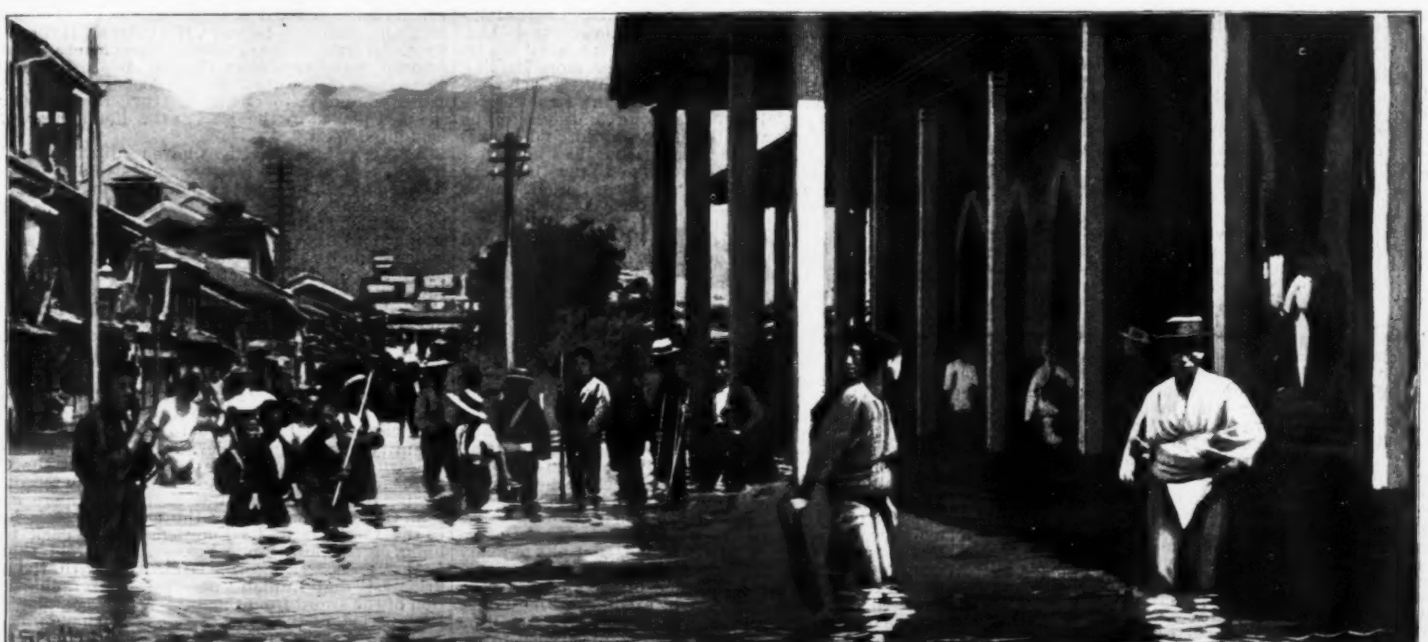
THE TIDAL WAVE IN JAPAN.

THERE have been few calamities involving the sudden loss of lives and property which have been so swift and altogether unlooked for as the recent tidal wave in Japan. Possibly there have been other calamities of greater magnitude as regards the total loss of life, but we look in vain to find another of this magnitude that has come upon a people literally without a moment's warning and in so short a time swept them by the thousand out of existence. Of all the recorded cataclysms of nature, this last tidal wave in Japan stands first in the awful suddenness with which it came. The tidal wave at Lisbon and the earthquake in Catalonia gave some premonitory signs of the coming disaster; but the unhappy dwellers on the northern coast of Japan were out in holiday garb and holding high carnival when the giant wave rolled in upon them and carried thirty thousand hapless souls out to sea amid the confused wreckage of their desolated homes.

The calamity happened on the evening of June 15, and, as fate would have it, this day had been set apart for the celebration of what is known as the Boys' Festival. The Japanese are never so happy as when engaged in their holiday and other festivals, and it seems that on this occasion the number of people who dwell on the strip of sea coast from Sendai to Amori, a distance of two hundred miles, was increased by a large influx of visitors who had come from the neighboring towns and villages in the interior.

There is no doubt but the disaster was largely increased by the frail nature of the Japanese buildings, which were too flimsy to offer any resistance to the rush of the tidal wave. Bamboo, wooden framing, thatched roofing, are an ineffectual barrier to the advance of a solid wall of water, and the homes of the wretched people were swept away from the foundations like so much stubble. Had the buildings been of stone and brick, standing upon secure foundations, there is no doubt but that the loss of life would have been much less than it was. This supposition is borne out by the facts of the Johnstown flood in this country, particularly in Johnstown itself. While the wooden buildings were overturned, or floated bodily from their foundations, the brick and stone structures stood in many cases comparatively secure. It is likely that many of the Japanese were killed outright or completely disabled by the crushing in of their frail tenements who otherwise might have survived when the waters receded.

The destruction appears to have been complete, especially among the weaker frame houses, as may be judged from our illustration of a street in Kobe. The more modern and substantially built structures, such as the railway station shown in the adjoining illustration, appear to have come out of the flood in fair condition. The destruction which occurred in Kobe is fairly representative of what took place over the whole of the inundated district. Whole towns were obliterated, and the dead bodies and the wreckage were carried out to sea. The scenes are spoken of as "indescribable." Picturesque villages which possessed all the cheerful and cleanly comfort so characteristic of a collection of Japanese homes were left a mere heap of



OUTSIDE VIEW OF KOBE STATION.

THE TIDAL WAVE IN JAPAN—WRECKED HOUSES IN KOBE.

muddy wreckage, from which protruded the lifeless bodies of the villagers. From the village of Hosoura a party of laborers had set out in the morning to work at a distant inland town. At night they returned to find their homes a dismal pool of salt water, in which were seen the ghastly skeletons of their ruined homes.

It is likely that the actual number of victims will never be known; but it is estimated that the total is not far short of 35,000.

The cause of these tidal waves can only be conjectured. The most likely theory is that they are caused by disturbances in the bed of the ocean, possibly by the closing up or "crumpling" of the earth's crust under the strains set up by cooling of the interior. The deepest marine soundings have been taken off the islands of Japan; and it would be natural for the contraction to take place in such a depression as that which runs approximately parallel with the Japanese coast. This would cause a displacement of the ocean at this point, which would travel in a wave from east and west until it had spent itself. We are indebted to Black and White for our illustrations.

THE BRITISH ASSOCIATION—ANTHROPOLOGY.*

TRAVELERS have ceased to seek for the "Terrestrial Paradise," but, in a broader sense, the area in which lay the cradle of civilized mankind is becoming generally recognized. The plateaus of Central Asia have receded from our view. Anthropological researches may be said to have established the fact that the white race, in the widest acceptation of the term, including, that is, the darker complexioned section of the South and West, is the true product of the region in which the earliest historic records find it concentrated. Its "Area of Characterization" is conterminous, in fact, with certain vast physical barriers due to the distribution of sea and land in the latest geological period. The continent in which it rose, shut in between the Atlantic and the Indian Oceans, between the Libyan Desert and what is now Sahara, and an icier Baltic stretching its vast arms to the Ponto-Caspian basin, embraced, together with a part of anterior Asia, the greater part of Europe and the whole of Northern Africa. The Mediterranean itself—divided into smaller separate basins, with land bridges at the Straits of Gibraltar and from Sicily and Malta to Tunis—did not seriously break the continuity of the whole. The English Channel, as we know, did not exist, and the old sea-coast of what are now the British Islands, stretching far to the west, is, as Prof. Boyd Dawkins has shown, approximately represented by the hundred-fathom line. To this great continent Dr. Brinton, who has so ably illustrated the predominant part played by it in isolating the white from the African black and the yellow races of mankind, has proposed to give the useful and appropriate name of "Eurafrica." In "Eurafrica," in its widest sense, we find the birthplace of the highest civilizations that the world has yet produced and the mother country of its dominant peoples.

It is true that later geological changes have made this continental division no longer applicable. The vast land area has been opened to the east, as if to invite the Mongolian nomads of the Steppes and Tundras to mingle with the European population; the Mediterranean bridges, on the other hand, have been swept away. Asia has advanced, Africa has receded. Yet the old underlying connection of the peoples to the north and south of the Mediterranean basin seems never to have been entirely broken. Their inter-relations affect many of the most interesting phenomena of archæology and ancient history, and the old geographical unity of "Eurafrica" was throughout a great extent of its area revived in the great political system which still forms the basis of civilized society, the Roman Empire. The Mediterranean was a Roman lake. A single fact brings home to us the extent to which the earlier continuity of Europe and North Africa asserted itself in the imperial economy. At one time, what is now Morocco and what is now Northumberland, with all that lay between them on both sides of the Pyrenees, found their administrative center on the Mosel.

It is not for me to dwell on the many important questions affecting the physiological sides of ethnography that are bound up with these old geographical relations. I will, however, at least call attention to the interesting, and in many ways original, theory put forward by Prof. Sergi in his recent work on the "Mediterranean Race."

Prof. Sergi is not content with the ordinary use of the term "White Race." He distinguishes a distinct "brown" or "brunette" branch, whose swarthier complexion, however, and dark hair bear no negroid affinities, and are not due to any intermixture on that side. This race, with dolichocephalic skulls, among which certain defined types constantly repeat themselves, he traces throughout the Mediterranean basin, from Egypt, Syria, and Asia Minor, through a large part of Southern Europe, including Greece, Italy, and the Iberic peninsula, to the British Islands. It is distributed along the whole of North Africa, and, according to the theory propounded, finds its original center of diffusion somewhere in the parts of Somaliland.

It may be said at once that this grouping together into a consistent system of ethnic factors spread over this vast yet inter-related area—the heart of "Eurafrica"—presents many attractive aspects. The ancient Greek might not have accepted kinship even with "the blameless Ethiopian," but those of us who may happen to combine a British origin with a Mediterranean complexion may derive a certain ancestral pride from remote consanguinity with Pharaoh. They may even be willing to admit that "the Ethiopian" in the course of his migrations has done much to "change his skin."

In part, at least, the new theory is little more than a re-statement of an ethnographic grouping that commands a general consensus of opinion. From Thurnam's time onward we have been accustomed to regard the dolichocephalic type found in the early Long Barrows, and what seem to have been the later survivals of the same stock in our islands, as fitting on to the Iberian element in Southwestern Europe. The extensive new materials accumulated by Dr. Garson have only served to corroborate these views, while further researches have shown that the characteristic features of the skeletons found in the Ligurian caves, at Cro Magnon and elsewhere in France, are common to those of a large part of Italy, Sicily, and Sardinia, and extend not only to the Iberic group, but to the Guanche interments of the Canary Islands.

The newly correlated data unquestionably extend the field of comparison; but the theories as to the original home of this "Mediterranean Race" and the course of its diffusion may be thought to be still somewhat lacking in documentary evidence. They remind us rather too closely of the old "Aryan" hypothesis, in which we were almost instructed as to the halting places of the different detachments as they passed on their way from their Central Asian cradle to rearrange themselves with military precision, and exactly in the order of their relationship, in their distant European homes. The existing geological conditions are made the basis of this migratory expansion from Ethiopia to Ireland: parallel streams move through North Africa and from Anatolia to Southern Europe. One cardinal fact has certainly not received attention, and that is, that the existing evidence of this Mediterranean type dates much further back on European soil than even in ancient Egypt.

Prof. Sergi himself has recognized the extraordinary continuity of the cranial type of the Ligurian caves among the modern population of that coast.

But this continuity involves an extreme antiquity for the settlement of the "Mediterranean Race" in Northwestern Italy and Southern France. The cave interments, such as those of the Finalese, carry back the type well into Neolithic times. But the skeletons of the Baoussé Roussé caves, between Mentone and Ventimiglia, which reproduce the same characteristic forms, take us back far behind any stage of culture to which the name of Neolithic can be properly applied.

The importance of this series of interments is so unique, and the fullness of the evidence so far surpasses any other records immediately associated with the earliest remains of man, that even in this brief survey they seem to demand more than a passing notice.

So much, at least, must be admitted on all hands; an earlier stage of culture is exhibited in these deposits than that which has hitherto been regarded as the minimum equipment of the men of the later Stone Age. The complete absence of pottery, of polished implements, of domesticated animals—all the more striking from the absolute contrast presented by the rich Neolithic cave burials a little further up the same coast—how is it to be explained? The long flint knives, the bone and shell ornaments, might, indeed, find partial parallels among Neolithic remains; but does not, after all, the balance of comparison incline to that more ancient group belonging to the "Reindeer Period" in the South of France as illustrated by the caves of La Madeleine, Les Eyzies and Solutré?

It is true that, in an account of the interments found in 1892 in the Barma Grande Cave, given by me to the Anthropological Institute, I was myself so prepossessed by the still dominant doctrine that the usage of burial was unknown to Paleolithic man, and so overpowered by the vision of the yawning hiatus between him and his Neolithic successor, that I failed to realize the full import of the evidence. On that occasion I took refuge in the suggestion that we had here to deal with an earlier Neolithic stratum than any hitherto recorded. "Neolithic," that is, without the Neolithic.

But the accumulation of fresh data, and especially the critical observations of M. D'Acy and Prof. Issel, have convinced me that this intermediate position is untenable. From the great depth below the original surface, of what in all cases seem to have been homogeneous quaternary deposits, at which the human remains were found, it is necessary to suppose, if the interments took place at a later period, that pits in many cases from 30 to 40 feet deep must have been excavated in the cave earth. But nothing of the kind has been detected, nor any intrusion of extraneous materials. On the other hand, the gnawed or defective condition of the extremities in several cases points clearly to superficial and imperfect interment of the body; and in one case parts of the same core from which flints found with the skeleton had been chipped were found some meters distant on the same floor level. Are we, then, to imagine that another pit was expressly dug to bury these?

In the case of a more recently discovered and as yet unpublished interment, at the excavation of which I was so fortunate as to assist, the superficial character of the deposit struck the eye. The skeleton, with flint knife and ocher near, decked out with the usual shell and deer's tooth ornaments, lay as if in the attitude of sleep, somewhat on the left side. The middle of the body was covered with a large flat stone, with two smaller ones lying by it, while another large stone was laid over the feet. The left arm was bent under the head as if to pillow it, but the extremities of the right arm and the toes were suggestively deficient: the surface covering of big stones had not sufficiently protected them. The stones themselves seem in turn to have served as a kind of hearth, for a stratum of charred and burned bones about 45 cm. thick lay about them.

Is it reasonable to suppose that a deposit of this kind took place at the bottom of a pit over twenty feet deep, left open an indefinite time for the convenience of roasting venison at the bottom?

A rational survey of the evidence in this as in the other cases leads to the conclusion that we have to deal with surface burial, or, if that word seems too strong, with simple "seposition"—the imperfect covering with handy stones of the dead bodies as they lay in the attitude of sleep on the then floor of the cavern. In other words, they are in situ in a late quaternary deposit, for which Prof. Issel has proposed the name of "Meiolithic."

But if this conclusion is to hold good, we have here on the northern coast of the Mediterranean evidence of the existence of a late Paleolithic race, the essential features of which, in the opinion of most competent osteological inquirers, reappear in the Neolithic skeletons of the same Ligurian coast, and still remain characteristic of the historical Ligurian type. In other words, the "Mediterranean Race" finds its first record in the West; and its diffusion, so far from having necessarily followed the lines of later geographical divisions, may well have begun at a time when the land bridges of "Eurafrica" were still unbroken.

There is nothing, indeed, in all this to exclude the hypothesis that the original expansion took place from the East African side. That the earliest homes of primeval man lay in a warm region can hardly be doubted, and the abundant discovery by Mr. Seton Karr in Somaliland of Paleolithic implements reproducing many of the most characteristic forms of those of the grottoes of the Dordogne affords a new link of connection between the Red Sea and the Atlantic littoral.

When we recall the spontaneous artistic qualities of the ancient race which has left its records in the carvings on bone and ivory in the caves of the "Reindeer Period," this evidence of at least partial continuity on the northern shores of the Mediterranean suggests speculations of the deepest interest. Overlaid with new elements, swamped in the dull, though materially higher, Neolithic civilization, may not the old æsthetic faculties which made Europe the earliest known home of anything that can be called human art, as opposed to mere tools and mechanical contrivances, have finally emancipated themselves once more in the Southern regions, where the old stock most survived? In the extraordinary manifestations of artistic genius to which, at widely remote periods, and under the most diverse political conditions, the later populations of Greece and Italy have given birth, may we not be allowed to trace the re-emergence, as it were, after long underground meanderings, of streams whose upper waters had seen the daylight of that earlier world?

But the vast gulf of time beyond which it is necessary to carry back our gaze in order to establish such connections will hardly permit us to arrive at more than vague possibilities. The practical problems that concern the later culture of Europe from Neolithic times onward connect themselves rather with its relation to that of the older civilizations on the southern and eastern Mediterranean shores.

Anthropology, too, has its "Eternal Eastern Question." Till within quite recent years, the glamor of the Orient pervaded all inquiries as to the genesis of European civilization. The Biblical training of the northern nations prepared the ground. The imperfect realization of the antiquity of European art; on the other hand, the imposing chronology of Egypt and Babylonia; the abiding force of classical tradition, which found in the Phœnician a deus ex machinâ for exotic importations: finally, the "Aryan Hypothesis," which brought in the dominant European races as immigrant wanderers from Central Asia, with a ready-made stock of culture in their wallets—these and other causes combined to create an exaggerated estimate of the part played by the East as the illuminator of the benighted West.

More recent investigations have resulted in a natural reaction. The primitive "Aryan" can be no longer invoked as a kind of patriarchal missionary of Central Asian culture. From D'Halloy and Latham onward to Penka and Schrader an array of eminent names has assigned to him a European origin. The means by which a kindred tongue diffused itself among the most heterogeneous ethnic factors still remain obscure; but the stricter application of phonetic laws and the increased detection of loanwords has cut down the original "Aryan" stock of culture to very narrow limits, and entirely stripped the members of this linguistic family of any trace of a common Pantheon.

Whatever the character of the original "Aryan" stage, we may be very sure that it lies far back in the mists of the European Stone Age. The supposed common names for metals prove to be either a vanishing quantity or strikingly irrelevant. It may be interesting to learn on unimpeachable authority that the Celtic words for "gold" are due to comparatively recent borrowing from the Latin; but nothing is more certain than that gold was one of the earliest metals known to the Celtic races, its knowledge going back to the limits of the pure Stone Age. We are told that the Latin "ensis," "a sword," is identical with the Sanskrit "asi" and Iranian "ahi," but the gradual evolution of the sword from the dagger, only completed at a late period of the Bronze Age, is a commonplace of prehistoric archæology. If "ensis," then, in historical times an iron sword, originally meant a bronze dagger, may not the bronze dagger in its turn resolve itself into a flint knife?

The truth is that the attempts to father on a common Aryan stock the beginnings of metallurgy argue an astonishing inability to realize the vast antiquity of languages and their groups. Yet we know that, as far back as we have any written records, the leading branches of the Aryan family of speech stood almost as far apart as they do to-day, and the example of the Egyptian and Semitic groups, which Maspero and others consider to have been originally connected, leads to still more striking results. From the earliest Egyptian stela to the latest Coptic liturgy we find the main outlines of what is substantially the same language preserved for a period of some six thousand years. The Semitic languages in their characteristic shape show a continuous history almost as extensive. For the date of the diverging point of the two groups we must have recourse to a chronology more familiar to the geologist than the antiquary.

As importer of exotic arts into primitive Europe the Phœnician has met the fate of the immigrants from the Central Asian "Arya." The days are gone past when it could be seriously maintained that the Phœnician merchant landed on the coast of Cornwall, or built the dolmens of the North and West. A truer view of primitive trade as passing on by inter-tribal barter has superseded the idea of a direct commerce between remote localities. The science of prehistoric archæology, following the lead of the Scandinavian school, has established the existence in every province of local centers of early metallurgy, and it is no longer believed that the implements and utensils of the European Bronze Age were imported wholesale by Semites or "Etruscans."

It is, however, the less necessary for me to trace in detail the course of this reaction against the exaggerated claims of Eastern influence that the case for the independent position of primitive Europe has been recently summed up with fresh arguments, and in his usual brilliant and incisive style, by M. Salomon Reinach, in his "Mirage Orientale." For many ancient prejudices as to the early relations of East and West it is the trumpet sound before the walls of Jericho. It may, indeed, be doubted whether, in the impetuousness of his attack, M. Reinach, though he has rapidly brought up his reserves in his more recent work on primitive

* Opening address by Arthur J. Evans, President of Section H, and published in Nature.

European sculpture, has not been tempted to occupy outlying positions in the enemy's country which will hardly be found tenable in the long run. I cannot myself, for instance, be brought to believe that the rude marble "idols" of the primitive Ægean population were copied on Chaldean cylinders. I may have occasion to point out that the oriental elements in the typical higher cultures of primitive Europe, such as those of Mycenæ, of Hallstatt, and La Tène, are more deeply rooted than M. Reinach will admit. But the very considerable extent to which the early European civilization was of independent evolution has been nowhere so skillfully focused into light as in these comprehensive essays of M. Reinach. It is always a great gain to have the extreme European claims so clearly formulated, but we must still remember that the "Sick Man" is not dead.

The proofs of a highly developed metallurgic industry of home growth accumulated by prehistoric students pari passu over the greater part of Europe, and the considerable cultural equipment of its early population—illustrated, for example, in the Swiss Lake settlements—had already prepared the way for the more startling revelations as to the prehistoric civilization of the Ægean world which have resulted from Dr. Schliemann's diggings at Troy, Tiryns and Mycenæ, so admirably followed up by Dr. Tsountas.

This latter civilization, to which the general name of "Ægean" has been given, shows several stages, marked in succession by typical groups of finds, such as those from the Second City of Troy, from the cist graves of Amorgos, from beneath the volcanic stratum of Thera, from the shaft graves of Mycenæ, and again from the tombs of the lower town. Roughly, it falls into two divisions, for the earlier of which the culture illustrated by the remains of Amorgos may be taken as the culminating point, while the later is inseparably connected with the name of Mycenæ.

The early "Ægean" culture rises in the midst of a vast province extending from Switzerland and Northern Italy through the Danubian basin and the Balkan peninsula, and continued through a large part of Anatolia, till it finally reaches Cyprus. It should never be left out of sight that, so far as the earliest historical tradition and geographical nomenclature reach back, a great tract of Asia Minor is found in the occupation of men of European race, of whom the Phrygians and their kin—closely allied to the Thracians on the other side of the Bosphorus—stand forth as the leading representatives. On the other hand, the great antiquity of the Armenoid type in Lycia and other easterly parts of Asia Minor, and its priority to the Semites in these regions, has been demonstrated by the craniological researches of Dr. Von Luschan. This ethnographic connection with the European stock, the antiquity of which is carried back by Egyptian records to the second millennium before our era, is fully borne out by the archæological evidence. Very similar examples of ceramic manufactures recur over the whole of this vast region. The resemblances extend even to minutiæ of ornament, as is well shown by the examples compared by Dr. Much from the Mondsee, in Upper Austria, from the earliest stratum of Hissarlik, and from Cyprus. It is in the same Anatolo-Danubian area—as M. Reinach has well pointed out—that we find the original center of diffusion of the "Svastika" motive in the Old World. Copper implements and weapons, too, of primitive types, some reproducing Neolithic forms, are also a common characteristic, though it must always be remembered that the mere fact that an implement is of copper does not of itself necessitate its belonging to the earliest metal age, and that the freedom from alloy was often simply due to a temporary deficiency of tin. Cyprus, the land of copper, played, no doubt, a leading part in the dissemination of this early metallurgy, and certain typical pins and other objects found in the Alpine and Danubian regions have been traced back by Dr. Naue and others to Cypriote prototypes. The same parallelism throughout this vast area comes out again in the appearance of a class of primitive "idols" of clay, marble and other materials, extending from Cyprus to the Troad and the Ægean islands, and thence to the pile settlements of the Alps and the Danubian basin, while kindred forms can be traced beyond the Carpathians to a vast northern Neolithic province that stretches to the shores of Lake Ladoga.

It is from the center of this old Anatolo-Danubian area of primitive culture, in which Asia Minor appears as a part of Europe, that the new Ægean civilization rises from the sea. "Life was stirring in the waters." The notion that the maritime enterprise of the Eastern Mediterranean began on the exposed and comparatively harborless coast of Syria and Palestine can no longer be maintained. The island world of the Ægean was the natural home of primitive navigation. The early sea trade of the inhabitants gave them a start over their neighbors, and produced a higher form of culture, which was destined to react on that of a vast European zone—nay, even upon that of the older civilizations of Egypt and Asia.

The earlier stage of this Ægean culture culminates in what may conveniently be called the Period of Amorgos from the abundant tombs explored by Dr. Dümmler and others in that island. Here we already see the proofs of a widespread commerce. The ivory ornaments point to the South; the abundance of silver may even suggest an intercourse along the Libyan coast with the rich silver producing region of Southeastern Spain, the very ancient exploitation of which has been so splendidly illustrated by the researches of the brothers Siret. Additional weight is lent to this presumption by the recurrence in these Spanish deposits of pots with rude indications of eyes and eyebrows, recalling Schliemann's owl-faced urns; of stone "idols," practically identical with those of Troy and the Ægean islands, here too associated with marble cups of the same simple forms; of triangular daggers of copper and bronze, and of bronze swords which seem to stand in a filial relation to an "Amorgan" type of dagger. In a former communication to this section I ventured to see in the so-called "Cabiri" of Malta—very far removed from any Phœnician sculpture—an intermediate link between the Iberian group and that of the Ægean, and to trace on the fern-like ornaments of the altar stone a comparison with the naturalistic motives of proto-Mycenæan art, as seen, for instance, on the early vases of Thera and Therasia.

A Chaldæan influence cannot certainly be excluded from this early Ægean art. It reveals itself, for instance, in indigenous imitations of Babylonian cylinders. My own conclusion that the small marble figures of the Ægean deposits, though of indigenous European lineage, were in their more developed types influenced by Istar models from the East, has since been independently arrived at by the Danish archæologist, Dr. Blinkenburg, in his study on præ-Mycenæan art.

More especially the returning spiral decoration, which in the "Amorgan Period" appears upon seals, rings, bowls and caskets of steatite, leads us to a very interesting field of comparison. This motive, destined to play such an important part in the history of European ornament, is absent from the earlier products of the great Anatolo-Danubian province. As a European design it is first found on these insular fabrics, and it is important to observe that it first shows itself in the form of reliefs on stone. The generally accepted idea, put forward by Dr. Milchhöfer, that it originated here from applied spirals on metal work is thus seen to be bereft of historical justification. At a somewhat later date we find this spiraliform motive communicating itself to the ceramic products of the Danubian region, though from the bold relief in which it sometimes appears, a reminiscence of the earlier steatite reliefs seems still traceable. In the late Neolithic pile station of Butmir, in Bosnia, this spiral decoration appears in great perfection on the pottery, and is here associated with clay images of very advanced fabric. At Lengyel, in Hungary, and elsewhere, we see it applied to primitive painted pottery. Finally, in the later Hungarian Bronze Age it is transferred to metal work.

But this connection—every link of which can be made out—of the lower Danubian Bronze Age decoration with the Ægean spiral system—itself much earlier in origin—has a very important bearing on the history of ornament in the North and West. The close relation of the Bronze Age culture of Scandinavia and Northwestern Germany with that of Hungary is clearly established, and of the many valuable contributions made by Dr. Montelius to prehistoric archæology, none is more brilliant than his demonstration that this parallelism of culture between the Northwest and Southeast owes its origin to the most ancient course of the amber trade from the North Sea shores of Jutland by the valley of the Elbe and Moldau to the Danubian Basin. As Dr. Montelius has also shown, there was, besides, a western extension of this trade to our own islands. If Scandinavia and its borderlands were the source of amber, Ireland was the land of gold. The wealth of the precious metal there is illustrated by the fact that, even as late as 1796, the gold washings of County Wicklow amounted to £10,000. A variety of evidence shows a direct connection between Great Britain and Scandinavia from the end of the Stone Age onward. Gold diadems of unquestionably British—probably Irish—fabric—have been found in Seeland and Fünen, and from the analysis of early gold ornaments it clearly results that it was from Ireland rather than the Ural that Northern and Central Europe was supplied. Mr. Coffey, who has made an exhaustive study of the early Irish monuments, has recently illustrated this early connection by other comparisons, notably the appearance of a design which he identifies with the early carvings of boats on the rocks of Scandinavia.

This prolongation of the Bronze Age trade route—already traced from the Middle Danube—from Scandinavia to Ireland, ought it to be regarded as the historic clew to the contemporary appearance of the spiral motive in the British Islands? Is it to this earlier intercourse with the land of the Vikings that we must ascribe the spiral scrolls on the slabs of the great chambered barrows of the Irish Bronze Age—best seen in the most imposing of them all, before the portal and on the inner chambers of New Grange?

The possibility of such a connection must be admitted; the probability is great that the contemporary appearance of the spiraliform ornament in Ireland and on the Continent of Europe is due to direct derivation. It is, of course, conceivable that such a simple motive as the returning spiral may have originated independently in various parts of Europe, as it did originate in other parts of the world. But anthropology has ceased to content itself with the mere accumulation of sporadic coincidences. It has become a historic study. It is not sufficient to know how such and such phenomena may have originated, but how, as a matter of fact, they did. Hence in the investigation of origins and evolution the special value of the European field where the evidence has been more perfectly correlated and the continuous records go further back. An isolated example of the simple volute design belonging to the "Reindeer Period" has been found in the grotto of Arudy. But the earliest cultural strata of Europe, from the beginning of the Neolithic period onward, betray an entire absence of the returning spiral motive. When we find it later propagating itself as a definite ornamental system in a regular chronological succession throughout an otherwise interrelated European zone, we have every right to trace it to a common source.

But it does not therefore follow that the only alternative is to believe that the spiral decoration of the Irish monuments necessarily connects itself with the ancient stream of intercourse flowing from Scandinavia.

We have to remember that the Western lands of gold and tin were the goals of other prehistoric routes. Especially must we bear in mind the early evidence of intercourse between the British Isles and the old Iberic region of the opposite shores of the continent. The derivation of certain forms of Bronze Age types in Britain and Ireland from this side has already been demonstrated by my father, and British or Irish bronze flat axes with their characteristic ornamentation have in their turn been found in Spain as well as in Denmark. The peculiar technique of certain Irish flint arrowheads of the same period, in which clipping and grinding are combined, is also characteristic of the Iberian province, and seems to lead to very extended comparisons on the Libyan side, recurring as it does in the exquisite handiwork of the non-Egyptian race whose relics Mr. Petrie has brought to light at Nagada. In prehistoric Spanish deposits, again, are found the actual walletlike baskets with incurving sides, the prototypes of a class of clay food vessels which (together with a much wider distribution) are of specially frequent occurrence in the British Isles as well as the old Iberian area.

If the spiral decoration had been also a feature of the Scandinavian rock carvings, the argument for derivation from that side would have been strong. But they are not found in them, and, on the other hand, the sculptures on the dolmens of the Morbihan equally show certain features common to the Irish stone chambers, including the primitive ship figure. The spiral itself does not appear on these; but the more the common elements between the Megalithic piles, not only of the old Iberian tract on the mainland, including Brittany, but in the islands of the West Mediterranean basin, are realized, the more probable it becomes that the impulse came from this side. The prehistoric buildings of Malta, hitherto spoken of as "Phœnician temples," which show in their primitive conception a great affinity to the Megalithic chambers of the earliest British barrows, bear witness on this side to the extension of the Ægean spiral system in a somewhat advanced stage, and accompanied, as at New Grange, with intermediate lozenges. In Sardinia, as I hope to show, there is evidence of the former existence of monuments of Mycenæan architecture in which the chevron, the lozenge, and the spiral might have been seen associated as in Ireland. It is on this line, rather than on the Danube and the Elbe, that we find in a continuous zone that Cyclopean tradition of domed chambers which is equally illustrated at Mycenæ and at New Grange.

These are not more than indications, but they gain additional force from the converging evidence to which attention has already been called of an ancient line of intercourse, mainly, we may believe, connected with the tin trade between the East Mediterranean basin and the Iberian West. A further corroboration of the view that an Ægean impulse propagated itself as far as our own islands from that side is perhaps afforded by a very remarkable find in a British barrow.

I refer to the Bronze Age interment excavated by Canon Greenwell, on Folkton Wold, in Yorkshire, in which, beside the body of a child, were found three carved chalk objects resembling round boxes with bossed lids. On one of these lids were grouped together, with a lozenge-shaped space between them, two partly spiraliform, partly concentric circular ornaments, which exhibit before our eyes the degeneration of two pairs of returning spiral ornaments. Upon the sides of two of these chalk caskets, associated with chevrons, saltires, and lozenges, were rude indications of faces—eyes and nose of bird-like character—curiously recalling the early Ægean and Trojan types of Dr. Schliemann. These, as M. Reinach has pointed out, also find an almost exact parallel in the rude indications of the human face seen on the sculptured menhirs of the Marne and the Gard valleys. To this may be added the interesting comparisons supplied by certain clay vessels, of rounded form, somewhat resembling the chalk "caskets" discovered by MM. Siret, in Spanish interments of the early metal age, in which eyes and eyebrows of a primitive style are inserted, as on the British relics, in the interspaces of linear ornamentation. The third chalk disk exhibits, in place of the human face, a butterfly with volute antennæ, reminding us of the appearance of butterflies as a decorative motive on the gold roundels from the shaft graves of Mycenæ, as also on early Mycenæan gems of steatite from Crete; in the latter case with the feelers curving outward in the same way. The stellate design with central circles on the lid of one of the chalk caskets is itself not impossibly a distant degeneration of the star flowers on the same Mycenæan plates. Putting all the separate elements of resemblance together—the returning spiral and star, the rude face and butterfly—the suggestion of Ægean reminiscence becomes strong, but the other parallels lead us for the line of its transmission toward the Iberian rather than the Scandinavian route.*

So much, at least, results from these various comparisons that, whether we find the spiral motive in the extreme West or North of Europe, everything points to the Ægean world as its first European center. But have we any right to regard it, even there, as of indigenous evolution?

It had been long my own conviction that the Ægean spiral system must itself be regarded as an offshoot of that of ancient Egypt, which as a decorative motive on scarabs goes back, as Prof. Petrie has shown, to the Fourth Dynasty. During the time of the Twelfth Dynasty, which, on general grounds, may be supposed roughly to correspond with the "Amorgan Period" of Ægean culture, it attained its apogee. The spiral convolutions now often cover the whole field of the scarab, and the motive begins to spread to a class of black bucchero vases, the chalk inlaying of whose ornaments suggests widespread European analogies. But the important feature to observe is that here, as in the case of the early Ægean examples, the original material on which the spiral ornament appears is stone, and that, so far from being derived from an advanced type of metal work, it goes back in Egypt to a time when metal was hardly known.

(To be continued.)

ALUMINUM AMALGAM.—H. Wislicenus and H. Kaufmann.—This neutral reduction agent is very serviceable for the dehydration of alcohol, ether, etc., as it reacts for water with a formation of hydrogen and aluminum hydroxide. Aromatic nitro compounds are reduced to amines, or, if the reaction is moderated, to substituted hydroxylamines, sodium nitrite to hydroxylamine, and even to ammonia, etc. In preparing the reagent, aluminum turnings, freed from oil, are treated with soda lye until a strong escape of hydrogen occurs; the surface is then rinsed with water and treated for two minutes with a one-half per cent. solution of sublimate. These operations are repeated after a short time; the preparation is then quickly washed with water, alcohol and ether, and the product kept under petroleum ether.—Berichte.

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* A further piece of evidence pointing in this direction is supplied by one of the chalk "caskets." On the upper disk of this, in the place corresponding with the double spirals on the other example, appears a degeneration of the same motive in a more compressed form, resembling two sets of concentric horseshoes united at their bases. This recurs at New Grange, and single sets of concentric horseshoes, or semicircles, are found both there and at Gavrinnis. The degeneration of the returning spiral motive extends therefore to Brittany.

ARMENIA AND ITS PATRIARCH.

We present an engraving of Monsignore Tchamtchian, the new Armenian Patriarch at Constantinople, for which we are indebted to the Illustrated London News. This journal gives the following particulars relating to him:

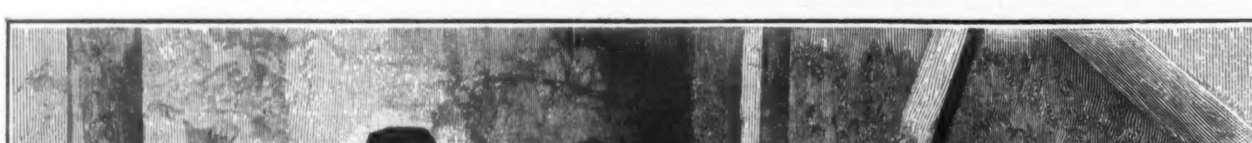
The suspension and exile by the Sultan's government of the Most Rev. Patriarch, or Metropolitan Bishop, of the Armenian community at Constantinople rendered it needful that a "locum tenens" should be appointed for the administration of the affairs of that church in the capital of the Turkish empire. An ecclesiastical personage, Monsignore Bartholomew Tchamtchian, has now been chosen for the office, not by the Assembly of Armenians, but through the intervention of a mixed council, the members of which are nominated by the Sultan. Monsignore Tchamtchian, supported by the class of government officials, was a candidate for the Patriarchate at the last election but one, and then obtained an equal number of votes with his Liberal opponent, Monsignore Khoren, of Lusignan; upon which some electors, of both parties, agreed to unite their suffrages in favor of a third person, Monsignore Askekian. Born in the city, he has always cultivated a friendly acquaintance with the influential Turks, and enjoys great favor among them, being a man of remarkable tact, and much of a courtier. He was first appointed pastor of the Armenian church of the Archangel, situated in the Jewish quarter, and celebrated for its fine old gates, of Byzantine workmanship. Having been consecrated a bishop by the late Catholicus George IV, he succeeded that prelate in the diocese of Broussa, and occupied the see during thirty years, after which he returned to the capital, about four years ago. Monsignore Tchamtchian is said, by those who belong to an opposition party, to be rather too ambitious and fond of display, as well as too solicitous of the approbation of powerful patrons. He is a man of imposing figure and presence, of large stature but corpulent, and appears to advantage in stately church ceremonials, but has not the reputation of great learning. The Sultan has recently bestowed upon him the decoration of the first class of the Order of the Medjidieh, an honor which had been refused by Monsignore Izmirlian, a prelate of very different character, in accordance with his sentiments regarding the conduct of his imperial majesty's government in permitting the massacres of the Armenians which have been perpetrated during the past two years.

The Armenian question has been endlessly discussed from all points of view, chiefly, however, from the English speaking standpoint. It would be tiresome to bring forward these interminable articles, but the Literary Digest presents some new matter which is worthy of consideration. It says that America is represented in Turkey chiefly in the persons of her Protestant missionaries, who are barely tolerated by the Mohammedan element, while they have made many friends and converts among the Armenians. The American press has naturally, therefore, followed the lead of England in denouncing the Turk most unreservedly. Germany, on the other hand, has in Turkey a military mission, whose members are on excellent terms with the Turks, but have little regard for the unwarlike Armenian. The result is that the reports of German travelers, for the most part reserve officers, differ materially from the opinions published in America. The Digest summarizes the articles of the botanist, Walter Siehe, who has been in Armenia for months, and who writes in the Deutsche Soldatenhart. The author reports what he saw and heard during a journey of more than a twelvemonth in Armenia. After praising certain characteristics of the Armenians, he declares that their moral standard is low. He says:

"During my entire stay of a year in Southeastern Asia Minor I have often been cheated and been robbed, and in each case this has been done by Armenians, and never by Turks."

The author maintains that for a number of years Armenia has been systematically covered with a network of American missions, which, in addition to religious purposes, aim at the education of the people. The Turkish authorities strictly forbid any Mohammedan subject from entering these schools. Among the Greek Christians proper the American missionaries gain but few proselytes; in nearly all cases their flocks consist of Armenians. It is not the purpose of these missionaries to meddle with political questions; but, without their wishing and desiring it, their pupils take a prominent part in the agitation. The Turkish government, not without good reasons, sees in these mission stations a danger; and, as the authorities cannot think of putting an end to them, the anger of the people is exhibited toward them in a manner which the Turks so thoroughly understand. The half education of the mission pupils makes them a kind of citizens that at times can become dangerous to the state. In addition, many Armenians have been in America, and the state of affairs there pleases them, and on their return they deplore

MONSIGNORE TCHAMTCHIAN, THE NEW ARMENIAN PATRIARCH AT CONSTANTINOPLE.



TURKISH COSTUMES.

the fate of their fellows more than ever. Notwithstanding the fact, then, that the missionaries have nothing to do with the Armenian uprising, it is from the indirect influence of the mission work that a large proportion of the people have become rebellious.

If the question is asked whether it is the fixed policy of the Turkish government to antagonize Christianity and persecute the Armenians for their faith's sake, this must be emphatically denied. I would rather be inclined to claim that in no country can the Christian church develop its individuality more freely than in Turkey. The Armenians themselves are filled with the hope of a resurrection of their political power and expect the restoration of their state.

These views are corroborated by the correspondents of such reliable papers as Allgemeine Zeitung, Berlin, the Frankfurter Zeitung and the Kölnische Zeitung, which agree with the St. James's Gazette, which says: "If the throwing of more bombs on the part of the Armenians is certain to result in fresh massacres, the moral is that they must stop throwing bombs."

The religious press in Germany is more in sympathy with the anti-Turkish movement in England and America.

There are not wanting in Germany secular periodicals which advocate interference on the part of the powers on the ground that it is the duty of Christian nations to assist their fellow Christians. The conservative Reichsbote, Berlin, gave space to a series of articles by Prof. Lepsius, in which the Armenian massacres were described with most shocking detail. This paper sums up the situation as follows:

1. That the massacres in Armenia, which have claimed about 100,000 victims in about 2,500 villages, as also the compulsory conversion of tens of thousands, were nothing more or less than an administrative measure of the Turkish government, in its kind a persecution of the Christians on a grand scale, the most terrible in all history.

2. That this measure, for which the central government in Constantinople gave the initiative, and which was undertaken and carried out with the active and the passive co-operation of the military and political officials, had the purpose of making impossible the carrying out of the promised reforms in the Armenian provinces, for which the powers were clamoring.

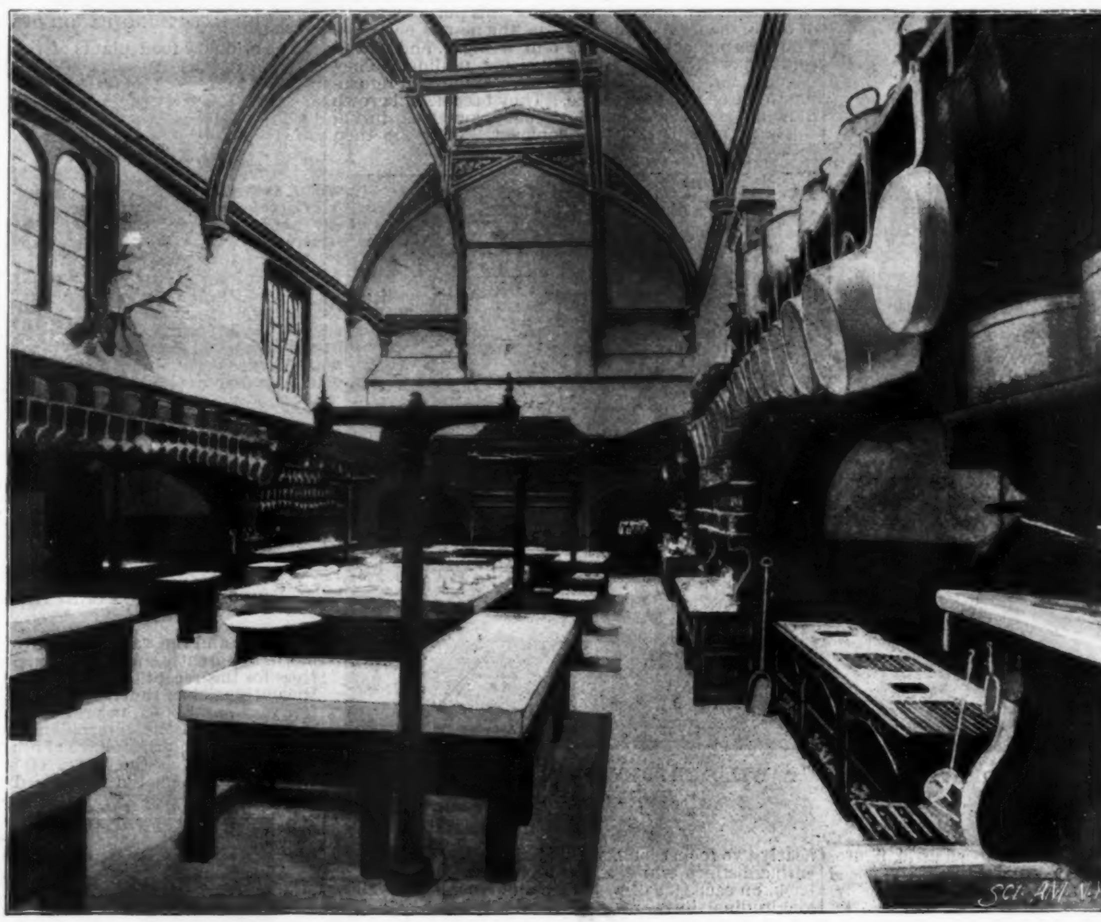
3. That the responsibility for the butchery and robbery and compulsory conversion of a Christian people of about 800,000 souls must rest upon the shoulders of the great powers, which, now that 100,000 Armenians have paid the price of the political wisdom of the powers, wash their hands in innocence and blame each other for the harm done.

Many Germans believe that Emperor William II alone can influence the Sultan, and they ask why he does not interfere on behalf of the Armenians.

We present an engraving of some of the Turkish friends of the German illustrated newspaper Ueber Land und Meer, showing characteristic costumes.

THE ROYAL KITCHEN, WINDSOR.

WINDSOR CASTLE, the principal residence of Queen Victoria, and one of the most stately, ancient and magnificent of royal palaces, is always attracting large numbers of tourists and sightseers, but we doubt whether many of these visitors ever penetrate to the apartment shown in the accompanying picture, made from a recent photograph, and for which we are indebted to St. James's Budget. The present private apartments of the Queen have been mostly rebuilt or remodeled within comparatively recent years, but many of the structures at Windsor date back five and six hundred years. The royal forest at Windsor contains about fifty thousand acres and is one of the grandest parks in the world. Many of the oaks in the forest date back to the time of William Rufus and William the Conqueror.



KITCHEN OF THE ROYAL PALACE, WINDSOR, ENGLAND.

THE NATIONAL CONDIMENT.

NEW JERSEY is the home of the tomato and especially of the national sauce of America, tomato ketchup, says the New York Tribune. Here the tomato plant attains its highest state of perfection and produces a fruit so luscious, red and round as to justify the old English name of "love apple," to which the French still cling, calling it pomme d'amour. The tomato plant being a native of America, and the name coming from the Indian word "tumati," it is fitting that tomato ketchup should be on every table in the land, and that America should furnish the choicest brands of the product for the whole world. The skill of the French cook is surpassed in this instance; if he wants real tomato ketchup, he must buy it in America.

Wide spreading acres are devoted in Jersey exclusively to the culture of tomatoes, the choicest ones of which are reserved for tomato ketchup. There are large factories in which ketchup making is the chief industry. A random visit to one of these factories is enough to convince the owner of the most jaded palate that there are flavors yet worth tasting. Tomatoes are put up in nearly half a hundred inconceivable ways, but chiefly in ketchup. The cooking is done on scientific principles. The original recipe for the ketchup produced, unlike that of a certain famous English sauce, probably came "from an old woman in the country," but the product has been so changed and improved by experiment that the old woman herself would be forced to admit that she had not attained the highest rank in her art.

The best efforts of at least two skilled men in one of the factories have been devoted to improving the flavor of the ketchup, but the result of their labors can be obtained by the general public only in the finished product. Their processes are carefully guarded secrets, kept locked up in their breasts. If both of them should die suddenly, the world would miss a distinctive product of the culinary art. The superintendent of the factory is one of these men. He probably knows as much about preserving fruits and making sauces as any man in the United States—and may be more than any other man. He tells an interesting story about the famous English sauce before mentioned.

The makers of the sauce did an enormous business and kept their recipe a secret. Thieves tried to steal it and other manufacturers imitated the flavor, the bottles, the labels, and so forth, but nobody succeeded in making sauce that was just like it. The rival manufacturers succeeded in getting decisions in their favor allowing them to use the same name and even to have similar coats of arms and labels, but the name of the original makers was a guarantee of the peculiar quality of their sauce.

One day the foreman of the big works had a quarrel with the proprietors and withdrew. He began making and placing on the market a sauce so nearly like the original that connoisseurs could not tell them apart. The foreman kept this up awhile, and then he suddenly retired from business, closed his works, stopped making sauce and lived in luxury thereafter. Nobody has any positive evidence as to the manner in which he acquired his wealth so suddenly, but some people can guess. No one else since then has been able to make sauce so nearly like the original.

"The secret of the tomato ketchup made here is just as carefully guarded as that," said the superintendent. "We say we make ketchup without the use of chemicals or coloring matter, and we do it. Salicylic acid is the standard chemical to prevent fermentation. If you can get just the right amount of that, perhaps it is not harmful: but the trouble is you have to use just a little to make sure that fermentation will not set in; and that surplus amount of salicylic acid hinders the natural fermentation of food in the stomach. It is as plain as that two and two make four.

"Then there is another thing, the coloring matter. These highly colored ketchups that look so bright are really not as pleasing to the eye as a ketchup that retains the natural color of the tomato, and they certainly are not so healthful, for they contain carmine. Any one who knows what carmine is made of doesn't care to eat it."

So much for the maker's estimate of his own product. The factory is certainly neat and aromatic. A whiff of the air there after dinner is almost as good as a dash of tomato ketchup. It requires 2,000 tons of tomatoes daily to supply the demand for the various preserves that are put up here. These are furnished largely by the farm in connection with the factory and partly by surrounding gardeners. The finest, reddest fruit is reserved for the ketchup making. It must be unbruised. This is placed in a scalding machine where, with two separate cold washings, and a hot plunge bath, the skin is loosened. Hence it goes into a peculiar machine called the "cyclone," which separates the skins and seeds from the pulp. Big porcelain-lined pumps take the pulp to a "sifter," where the coarser fibers are taken out and nothing but the blood red fluid percolates through, to be made into ketchup. Even this refining process is not enough, for the water is separated from it, and the clear pulp is then placed in large hermetically sealed cans, where it is cooked without foreign substances of any kind as a preservative.

These cans are taken down throughout the year as occasion demands, and the real process of making ketchup from the essence of the tomato begins. The pulp goes through more sifting machines that make it smooth like cream, and is placed in large tin-lined kettles where it is boiled and seasoned. Country girls with fresh Jersey complexions stir it up meanwhile, and the spices—what they are only two men know—are added. It is then tomato ketchup ready for the bottles, buckets and barrels that await it; for ketchup is made by the barrel and shipped by the ton.

THE FLIGHT OF BIRDS.

THE French scientific weekly, Ciel et Terre, prints in a recent issue a very interesting article about the speed of flying birds. This theme has lately been repeatedly touched on by scientists, but greatly exaggerated figures have found their way into print. Among these is, for instance, the statement of the Italian ornithologist, Professor Spallanzani, according to whom the common swallow is able to fly 290 feet per second. Experiments were made with four pigeons, which are said to have covered the distance from Paris to Buda-Pesth, about 807 miles, in seven hours, which would amount to an average speed of 165 feet per second. These figures are now made doubtful by very interesting tests made by August Verschuren, of Antwerp. He sent several baskets of pigeons to Compiegne, France, and

in a separate cage a swallow which had its nest under the gable roof of the railroad station at Antwerp. On August 17, at 7:30 in the morning, all the birds were liberated at Compiegne; the swallow took a northern direction as quick as lightning, while the pigeons made several spirals in the air before they started in the same direction. The swallow arrived at its nest in Antwerp at 8:23, a number of witnesses being present at its arrival. The first pigeons only arrived at their destination at 11:30 of the same morning. The swallow had, therefore, covered the entire distance of 146½ miles in one hour and eight minutes, which is equal to a speed of 128½ miles per hour, or about 189 feet per second, which is equal to more than double the average speed of the fastest train in the world. The pigeons only reached a speed of 35 miles an hour, or 48 feet per second. It may be gathered from these figures how rapidly the migrations of swallows take place, as with the speed mentioned above it would take them only half a day to fly from Belgium or central Germany to northern Africa.

Other careful measurements about the speed of carrier pigeons show results similar to those arrived at by Verschuren. Of 300 full grown pigeons, about 12 per cent. attained a speed of 60 feet per second at distances of from 95 to 125 miles. At distances of from 50 to 100 miles the average was but a trifle less. The maximum attained in any case was from 68 to 70 feet per second. For very short distances pigeons have been observed to fly 104 feet per second, but in long distances this speed can never be attained, for pigeons will not fly in a straight line, but, following the currents of the air, they describe zigzag lines. In the trials of pigeon flying by the Paris daily, Petit Journal, the highest speed attained was also 68 feet per second over a distance of 95 miles from Abbeville to Paris. This establishes the mean speed of pigeons at an average of 48 feet per second, and the highest speed at 70, figures which are rather conservative, considering the speed claimed for some exceptionally high-priced birds.

THE TENT CATERPILLAR.*

By CLARENCE M. WEED.

AMONG the many insect pests of the Granite State none is more in evidence during spring and early summer than the tent caterpillar,† which for more than a century has ravaged the orchards of New England. In 1790 Samuel Dean wrote from Portland, Mass.: "The principal inconvenience the farmer meets with from caterpillars is the damage they do to his orchard. A hairy kind of caterpillars build their nests on apple trees in May, and are gone entirely in June. But they feed so industriously on the leaves as to destroy a great part of them if they be not timely prevented. As they are far less mischievous than the canker worm, so they are more easily subdued."‡

Apparently, many people do not realize the seriousness of the injury when a fruit tree is stripped of its leaves. In its effort to repair the damage the tree will put out new foliage, thereby using up the stored materials that otherwise would be utilized for growth or fruit. Even in case no blossoms appear the season the damage is done, so that no loss of fruit that year may be felt, the effects will be evident in next year's crop.

The injury done by the tent caterpillar is at once distinguished from that of the canker worm by the fact that the former eats the body of the leaf, veins and all, leaving only the midrib or larger veins (Fig. 3), while the canker worm feeds upon the surface of the leaf, leaving the brown network of veins. A severe attack of the tent caterpillar renders the tree almost as bare in June as it is in midwinter—a condition shown in the illustration of the wild cherry tree—while a similar attack by the canker worm gives the tree a brown appearance, as if it had been scorched by fire.

* From Bulletin 38, New Hampshire College Agricultural Experiment Station, Durham.
† Clisiocampa americana.
‡ New England Farmer or Georgical Dictionary, 1790, p. 41.

BEECH TREE DEFOLIATED BY TENT CATERPILLARS.

A WILD CHERRY TREE IN "THE LEAFY MONTH OF JUNE."

THE HISTORY OF A CATERPILLAR'S LIFE.

Few insects pass so long a portion of the year within the eggs as do the tent caterpillars. In July the eggs are laid in masses of 200 or more in a cylindrical cluster upon the twigs of apple and wild cherry. After they are deposited the parent moth covers them with a viscid liquid, which dries into a sort of varnish that completely coats them, as represented in Fig. 4. The insect remains in this egg state from July until the following spring, when the little caterpillars emerge from the eggs and begin feeding upon the tender foliage of the buds about them. In a few days they begin to make a silken tent, utilizing generally, for this purpose, a fork of the branch. As time goes on the nest is enlarged. The caterpillars retire to the tent at night, and during cold and wet weather, and when not feeding. They have regular times for their meals, leaving and returning to the nest in processions. They become full grown in about six weeks, being extremely voracious during tha latter part of their development. They are then nearly two inches long, with a hairy body, ornamented with a distinct white stripe along the middle of the back, on each side of which are numerous short, yellow longitudinal lines, rather irregularly arranged. The sides are partially covered with paler lines, spotted and streaked with blue, while the lower surface of the body is black. The full grown caterpillar is represented in Fig. 5.

FIG. 3.—APPLE LEAVES EATEN BY TENT CATERPILLARS (Original).

FIG. 4.—EGG MASS (Original).

When the caterpillars become full grown most of them leave the tree where they have developed, and crawl about in search of shelter. Early in June thousands of these caterpillars may be seen rapidly crawling along the ground, especially by the roadside. When they find a satisfactory situation, beneath a board, in the cracks of a fence or between pieces of rough bark, they spin an oval, silken cocoon (Fig. 6), yellow when completed, within which they change to the quiet pupa or chrysalis state.

Two or three weeks later another change takes place, and from each cocoon there comes forth a reddish brown moth (Fig. 7). The male moths are considerably smaller than the females. These moths are nocturnal, flying only at night, and are to be found throughout the greater part of July. The females deposit the eggs upon the twigs of trees and soon die. As already stated, these eggs remain unhatched until the following spring.

THE EXTENDING RANGE OF FOOD PLANTS.

The ordinary food plants of the tent caterpillar are the apple and the various kinds of wild cherry. The moths apparently choose these in preference to all other trees for the reception of the egg masses. But during the outbreaks of the insect in New England the last few years, as, in fact, in previous outbreaks in other regions, many of the caterpillars have been forced by hunger to attack the foliage of other trees and shrubs. In many localities the leaves of the apple and cherry trees upon which the insects fed when first hatched have been wholly devoured before the caterpillars were half grown. Of course this must be the result when more egg masses are laid upon a tree or shrub than can be matured upon its leaves. Thus threatened by starvation the caterpillars have been forced to leave their nests, descend to the ground, and crawl about in search of food. Many of them ascend the nearest trees and shrubs, and nibble at their leaves. If these leaves are not too distasteful, the caterpillars are likely to remain and complete their growth upon the new food plant thus found.

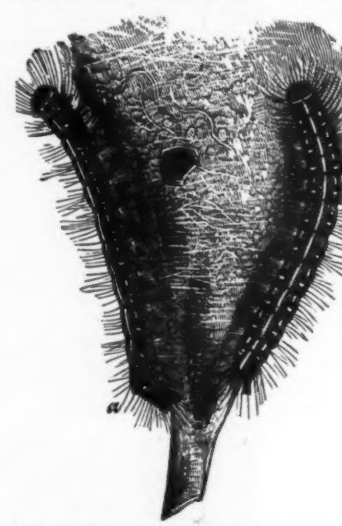


FIG. 5.—TENT CATERPILLAR (After Riley).

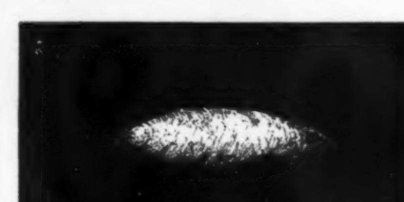


FIG. 6.—COCOON OF TENT CATERPILLAR (Original).

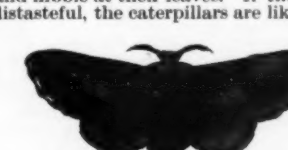


FIG. 7.—FEMALE MOTH (After Riley).

But it is very probable that many of these caterpillars which are able to complete their larval growth upon new food plants will survive all vicissitudes and mature into moths that apparently are likely to deposit eggs upon the variety of tree that has furnished them

food. In this way the insect will be likely soon greatly to extend the limits of its food supply and become much more difficult to subdue than it now is. The case is suggestive of the famous gypsy moth that has lately been causing such alarm in Massachusetts.

That this is not an imaginary danger can be seen from Fig. 8, showing the work of the tent caterpillar

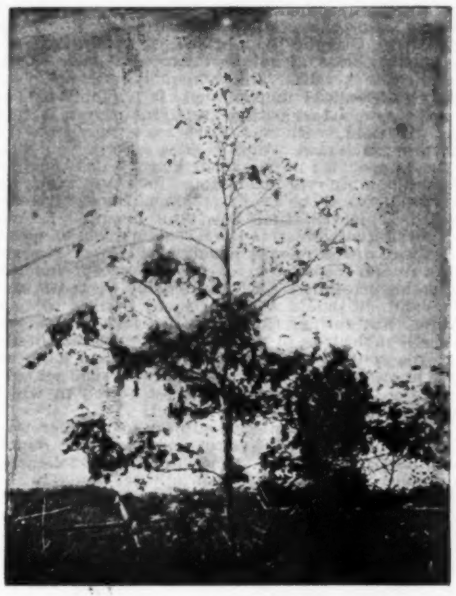


FIG. 8.—OAK TREE PARTIALLY DEFOLIATED BY TENT CATERPILLARS (Original).

upon trees and shrubs not on its usual bill of fare. It is well known that insects have family preferences in the matter of food; that if a given insect feeds upon a given plant, we need not be surprised to find it also upon another plant closely related, belonging to the same family.

In view of this we should expect the tent caterpillar when it was forced to increase its range of food to attack the peach, cultivated cherry, rose, and other plants of this family. This has been done, and each of these is now on the tent caterpillar's food list, but we have also found it feeding freely and apparently thriving upon such widely separated plants—so far as botanical kinship is concerned—as the oaks (Fig. 8), the hickories, the birches, the barberry, and the willows and poplars. I found a large tent even upon the low evergreen known as the juniper, but the caterpillars from it evidently fed upon a neighboring barberry.

DISEASES AND OTHER NATURAL ENEMIES.

During the latter part of the caterpillar season one can frequently find dead and dying caterpillars upon the outside of the tent, stretched at full length. Some of these will be simply sluggish, others evidently nearly dead, others dead and rupturing at a touch, letting escape the liquid decomposed body contents. Some will be hanging by one end of the body to the tent or twig, as shown in Fig. 9. These caterpillars appear to be affected by one of the bacterial diseases that are

FIG. 9.—DISEASED TENT CATERPILLARS (Original).

known to develop in many insect larvæ when they become very abundant. The army worm and common cabbage worm are frequently destroyed in great numbers by such diseases.

After the tent caterpillars are half grown there may be found in many of the nests small dead specimens with the body swollen and the skin dry and hard. (Fig. 10). If these are placed in bottles by themselves, a

FIG. 10.—PARASITIZED CATERPILLAR (Original).

fortnight or so later small four-winged flies will emerge from them. These are parasitic ichneumon flies. They have developed from eggs placed in the young caterpillars by similar parent flies, the eggs hatched into grubs or larvæ that developed on the inside of the caterpillars, killing them and absorbing all the bodies except the skin.

Comparatively few birds feed upon hairy larvæ like the tent caterpillar, but some, like the cuckoos and blue jays, devour them eagerly. Many observers have noticed that both the black-billed and the yellow-billed cuckoos feed upon the tent caterpillars. For example, Mr. C. E. Bailey states:* "On May 10 a black-billed cuckoo came into a tree near me at 3 P.M., and sat there until 4:40 P.M., then he went straight to a tent caterpillar's nest. He looked it over for a short time, and then commenced eating the caterpillars. He picked twenty-seven caterpillars out of the nest before he stopped. The bird ate them all and did not drop one."

Mr. E. H. Forbush gives* the following list of birds found feeding on tent caterpillars in a Massachusetts orchard in 1895: Crow, chickadee, Baltimore oriole, red-eyed vireo, yellow-billed cuckoo, black-billed cuckoo, chipping sparrow, yellow warbler.

My observations upon the natural checks upon the tent caterpillar lead me to believe that it is not good

FIG. 11.—YELLOW-BILLED CUCKOO (After Brehm).

policy to depend upon them for subduing the pests. It will be much better for the intelligent people of each community to attempt to arouse public opinion, so that each man will destroy the caterpillars upon his own premises and along the adjoining roadsides.

METHODS OF DESTROYING TENT CATERPILLARS.

1. Destroying the Eggs.—During winter and early spring the egg masses may readily be seen upon the smaller branches, and are easily removed and burned. In this work boys may be employed to advantage; their sharp eyes and nimble limbs are likely to accomplish as much as their elders. A few winters since a society in a Massachusetts town offered prizes to the youngsters of the community for the collection of the tent caterpillar egg masses, and thousands were thus destroyed. The same result may to a large extent be accomplished by cutting off and burning the thickets of wild cherry that line the roadsides and stand in clusters in pastures and fields. This should be done after the eggs are laid, and before they are hatched—any time between September 1 and April 1 would do. Such a burning of the wild cherry would also destroy millions of spores of black knot—the fungous disease

FIG. 12.—ASBESTOS TORCH.

that is always threatening cultivated plums and cherries because of its almost universal presence on the wild cherries. The pest-breeding, neglected apple trees bearing natural fruit, so often seen along the roadside, should also be converted into firewood, and the branches burned during fall or winter.

2. Killing the Young Caterpillars.—When the caterpillars are young and the nests are small, it is easy to destroy the colony by swabbing it out of the crotch with a mass of rags, a gloved hand, a forked stick, a scrubbing brush, or almost anything that can be used to crush the tiny worms huddled beneath the tent. In rainy weather one can generally find them in the tent almost any time, while in fair weather they may be attacked either early or late in the day. "A slender pole long enough to reach the highest nest in the tree," writes Mr. A. S. Fuller, "with two or three shingle nails driven through the end, leaving the heads sticking out a half inch, makes a very handy and efficient implement for dislodging the nest and caterpillars. By thrusting the end into the tent and then twisting it around two or three times the tent will be rolled about the end and can be drawn forth with contents," and destroyed.

There appears to be a considerable variation in the time of hatching of the different egg masses, so that it is often necessary to go over the trees more than once to get all the nests. As a rule, one should not be satisfied with a single attack upon the pests, but should renew the battle if necessary.

3. Burning with Torches.—A rather common method of destroying tent caterpillars is to burn them out by means of some substance saturated with kerosene. An asbestos torch advertised by the seedsmen and implement dealers for this purpose is represented in Fig. 12. The asbestos is saturated with kerosene, lighted and held under the tents for the cremation of the caterpillars. Rags tied to the end of a pole and saturated with kerosene are also used, as well as various other devices. But burning is a remedy which is likely to cause more harm than good. I have seen a fine young apple tree killed by the use of a torch on its tent caterpillars, and have known many larger trees to be seriously injured in the same way.

4. Spraying with the Arsenites.—On many accounts there is no more satisfactory method of subduing the tent caterpillar in the orchard than by spraying with Paris green or London purple mixed with water. Not only is this pretty certain to kill off all the young

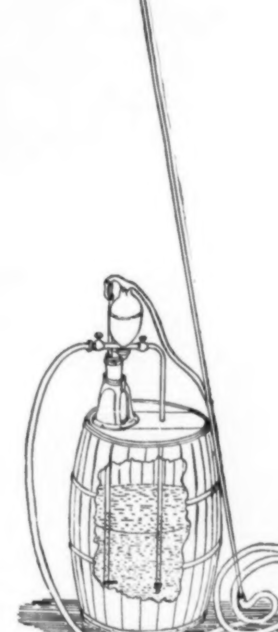


FIG. 13.

caterpillars on the trees, but it also destroys canker worms and also other leaf eating caterpillars as well as the larvæ of the codling moth or apple worm, discussed in Bulletin 35 of this station.

Fortunately spraying has been adopted by a great many commercial fruit growers as an essential part of the season's operations, and the practice is growing in favor yearly. Four or five ounces of Paris green, with a pint or two of fresh lime water, are added to a barrel holding forty or fifty gallons of water, thoroughly

* Massachusetts Crop Report, July, 1895, p. 29.

mixed and sprayed upon the trees soon after the worms hatch, by means of a force pump and spray nozzle. A simple and effective spraying outfit, which has been used to good advantage in the experiments at this station, is represented in Fig. 13. It consists of a kerosene barrel holding fifty gallons, a force pump having a double discharge, with a short line of hose running into the barrel to keep the liquid stirred, and a long line of hose fitted at the end to a slender brass rod

FIG. 14.—TENT CATERPILLAR ON OAK (Original).

tipped with a spray nozzle. The outfit can be obtained through any hardware dealer, or direct from any of the numerous manufacturers of spraying machinery.

TRICHOPILIA COCCINEA.

BY the kindness of Sir Trevor Lawrence, Bart., says the Gardeners' Chronicle, we are enabled to give an illustration of a very fine specimen of Trichopilia coccinea which he saw in the gardens of Mr. Otto Froebel at Zurich, and a photograph of which he obtained, and forwarded to us, remarking: "It is one of the finest examples of successful cultivation I have ever seen."

Probably, since its first introduction from Central America, where Warscewicz discovered it in 1849, no plant of equal beauty to this has flowered in gardens: and such a display of carmine crimson flowers among the bright green pseudo-bulbs and foliage must form a charming picture, some idea of which a glance at our illustration will give.

TRICHOPILIA COCCINEA—GROWN BY HERR OTTO FROEBEL, ZURICH.

DEPTHS OF THE HEAVENS.

IN the recent progress which has been made in the study of the heavens, the photographic plate has played a most important part. Indeed, the facilities which the resources of photography have placed at the disposal of the astronomer are every day increasing. The older methods of observation are in many cases gradually being displaced by the more accurate and far more comprehensive methods which the camera offers. It has been asserted, and I do not think that the truth of the assertion will be questioned, that the advance in the astronomer's art, which is due to the introduction of the photographic plate into the observatory, is not less far reaching in its effects than the advance which was inaugurated when Galileo first turned his newly made telescope to the sky, and thus wonderfully augmented the space penetrating power of human vision.

Almost the first feature which will strike the observer who is examining a good photograph of the sidereal depths is that, though there may be hardly any part of the area presented which is quite free from stars, yet that they are distributed with very great irregularity. In some regions the stars are aggregated in countless myriads; indeed, in many parts of the heavens they lie so closely packed that the individual points can hardly be distinguished separately. Ordinary observation, even with the unaided eye, prepares us in a measure for this striking irregularity in stellar distribution.

Who has not often dwelt with admiration on that glorious stellar girdle which we know as the Milky Way? It is a mighty zone of stars surrounding our solar system. Indeed, a just estimate of the relation of the sun to other bodies in the scheme of the universe would regard our great luminary merely as one of similar stars aggregated in countless myriads to form the Milky Way. From the peculiar nature of the stars in the Galaxy, as this system is often called, it is quite obvious that these wonderful starry clusters have some bond of connection between their component parts due probably to a common origin. To realize the splendor of the Milky Way we have to remember that, minute as the stars of which it is composed may seem from where we are situated, yet each one of these stars is in truth shining with the independent brilliancy of a sun. It might have been thought that it would have been quite impossible for an object so vast and so bright as our sun to display no greater splendor than that feeble twinkle which is all that reaches us from one of the stars in the Milky Way. Here, however, the question of distance is of paramount importance.

If the sun which shines in our skies were to be withdrawn from our neighborhood into the depth of space, if it were to be carried to a distance as remote as is that of many of the stars which we see around us, our great luminary would have lost all of its pre-eminent splendor, and would have dwindled to the relative insignificance of a small star not nearly so bright as many of those stars which shine over our heads every night. I do not, indeed, say that each and every one of the stars in the Milky Way is as large as our sun; no one who understood the evidence would have the hardihood to affirm so gigantic a proposition. At the same time I should add that I do not know any grounds on which such a statement could be certainly contradicted if any one did affirm it. The probability seems to be that, though many of the stars in the Milky Way may resemble our sun in luster or dimensions, yet there are in that marvelous group suns lesser and greater in nearly as many grades of magnitudes as there are objects in the Galaxy itself.

The problem of determining the distance of a star from the earth is one which taxes the highest resources of the observing astronomer. Of all the millions of the celestial host there are hardly 100 stars whose distances have been measured with accuracy by those surveying operations by which alone this problem can be accurately solved. We are, however, not quite destitute of methods by which we can in some degree estimate the remoteness of other stars, even though the distances may be so great as to elude entirely all the more direct methods of measurements. Suppose that a star were just bright enough to be visible to the unaided eye, and then suppose that particular star were to be withdrawn to a distance ten times as great. It would still remain visible to us by the help of a small telescope. If the star were withdrawn to a distance 100 times as great, it would still generally remain within the ken of a large telescope. When, therefore, our large telescopes reveal millions of stars, which seem just on the verge of visibility, it is plain that those stars, assuming that they are intrinsically as bright as the stars which can just be seen with the eye, must be at least 100 times as remote.

It should also be observed that a star as bright as Sirius would still be visible to the unaided eye, though, of course, only as a very small point, if it were translated to a distance ten times as great as that at which it is now situated; if Sirius were at a distance 100 fold greater than that at which it now lies, it would still be found within the range of a telescope of moderate power. Indeed, if Sirius were at a distance 1,000 times as great as that by which it is at present separated from us, it would still not have passed beyond the ken of our mightiest telescope. We have thus sound reasons for our belief that some of the stars which we can see through our great telescopes are at least 1,000 times as remote as Sirius.

Recent researches made by Dr. Gill and Dr. Elkins, at the Cape of Good Hope, have demonstrated what the distance of Sirius amounts to. It has been shown that the rays from Sirius, traveling as they do with the stupendous speed of light, namely, at the rate of 180,000 miles each second, would nevertheless require not less than nine years to traverse the distance between that star and our system. In other words, when we are looking at Sirius to-night we do not see that star as it is at present, but we see it as it was nine years ago. The light which reaches our eyes to-night must, in fact, have left the star nine years before. We have already shown that there is good reason for the belief that there are stars which are still visible in our great telescopes, notwithstanding that they are 1,000 times further from us than the brilliant Sirius. It follows by a line of reasoning which it seems impossible to question, that the light of such a star must have occupied a period of not less than 9,000 years in its journey to the earth. The consequences of such a calculation are indeed momentous. It is plain that we do not see such stars as they are to-night, but as they were when our earth was 9,000 years younger. The light from such stars which is now entering our eyes at the close of this unparalleled journey has occupied all that long interval in crossing the abyss which intervenes between the solar system and the awful stellar depths. This vast time has been required for the journey, notwithstanding the fact that the light speeds on its way with a velocity which would carry it seven times around the earth in a second. Indeed, the stars might have totally ceased to exist for the past 9,000 years and we should still find them shining in their places. Not until all the light which was on its way to earth at the time of the star's extinction had entered our eyes would the tidings of that extinction have become known to us. We are looking at such stars as they existed long before the earliest period to which any records of human history extend.

We can illustrate the same subject in another way. Suppose that there were astronomers in those remote stars, and that they were equipped with telescopes enormously more powerful than any telescopes which we have ever constructed. Suppose that, notwithstanding the vast distance at which they lie, they had the means of scrutinizing carefully the features of this earth. In what condition would our globe be presented from this point of view? These distant observers would not see any traces of the cities and the nations that now exist. Britain would appear to them as a forest inhabited by a few savages, and North America would be the home of the bison and the red man. They would look down on an Egypt in which the pyramids had not yet been built, and they might survey the sites of Babylon and Nineveh long ere those famous cities had been reared.

Besides those sidereal objects of which we have spoken there are of course others seemingly as numerous as the sands on the seashore. No spectacle which the heavens display is more impressive to the beholder than that of a globular cluster, in which thousands of stars are beheld packed closely together within the limits of his field of view. Each of those stars is itself a sun, the whole forming a dense group of associated suns. Indescribable indeed must be the glory which would shine upon a planet which was situated in such a system. It seems, however, impossible that planets in association with thousands of suns, such as are found in a globular cluster, could possess climatic conditions of sufficient constancy to meet the requirements of organic life.

For the development of life practical stability of climate would seem to be essential. Such conditions could, so far as we know, only be secured in a system like our own, which is controlled by a single sun around which the several planets revolve. In such a case there would be no disturbances to the regular motion of each planet, except those trifling ones arising from the attraction of the other planets equally beholden to the central luminary. But a planet primarily attached to one of the suns belonging to a globular cluster would be so much disturbed in its revolution by the attractions of the other surrounding suns that the movement of the body would in all probability be too irregular to be compatible with any stable climatic conditions. The vicissitudes of climate with which we dwellers on the earth are familiar would seem as nothing in comparison with the vicissitudes of climate in a planet belonging to a system of several suns. It would seem that occasionally the planet must come so near to one or other of the attracting suns that if any life had existed on such a planet it would necessarily be scorched to destruction.

Besides these globular clusters, the heavens contain many other associations of stars arranged in striking groups. We may mention, for instance, the famous cluster in Perseus, an object of indescribable beauty, which fortunately lies within the reach of telescopes of comparatively moderate power. There are also many clusters so distant that the stars are hardly to be discerned separately, in which case the object looks like a nebula, and the resolution of the nebula, as it is called—that is, the perception of the isolated stars of which the nebulous-looking object is formed—becomes a problem which can only be solved by the very highest telescope power.

It has been conjectured that these dim and distant clusters may be associations of stars very like that Milky Way which is relatively quite close to the solar system. It may, indeed, be the case that a sidereal group like the Milky Way would, if transferred to an extremely remote part of the universe, present much the same appearance in our telescopes as one of these nebulous clusters does at present.

Magnificent as are all the sidereal systems displayed to our observation, we ought still to remember that there is a limit to our vision. Even the largest and most brilliant of suns might be so remote as to be entirely beyond the ken of the greatest of telescopes and the most sensitive of photographic plates. Doubtless stars exist in profusion elsewhere than in those parts of space which alone come within range of our instruments. As space is boundless, it follows that the regions through which our telescopes have hitherto conveyed our vision must be as nothing in comparison with the realms whose contents must ever remain utterly unknown. Innumerable as may seem the stars whose existence is already manifest, there is every reason to believe that they do not amount to one-millionth part of the stars which occupy the impenetrable depths of the firmament.—Robert Ball, in New York Sun.

The highest points of the three Swiss railway tunnels, the Mont Cenis, St. Gothard and the Simplon, are 1249·70, 1154·60 and 705·20 meters above sea level respectively.

ENGINES OF TORPEDO BOAT DESTROYERS SALMON AND SNAPPER.

WE publish herewith an illustration of the engines of the torpedo boat destroyers Salmon and Snapper, designed, built, and engined for the Admiralty by Earle's Shipbuilding and Engineering Company, of Hull. These two vessels, which are of the 27 knot torpedo boat destroyer class, after successfully completing their speed and consumption trials, were delivered last year at Chatham Dockyard.

The length of these vessels is 200 ft.; breadth, 19 ft. 6 in.; and displacement in service trim and steam up about 250 tons. They are built entirely of steel of light scantling. The whole of the material used was galvanized by the builders by means of their electro-deposition plant. The armament consists of two torpedo tubes, one 12 pounder gun mounted on the top of a conning tower, and five 6 pounders, two of which are mounted on each broadside, and one on a raised platform aft.

The main propelling machinery, also designed by the builders, consists of two sets of triple compound engines, each set having three cylinders, the diameters of which are as follows: High pressure, 19¼ in.; medium pressure, 28½ in.; low pressure, 43 in. The length of the stroke is 18 in. It will be seen by reference to the illustration that these engines are somewhat novel in design, especially as regards the framing, the usual turned and polished steel back columns having been replaced by manganese bronze frames designed to carry the piston rod guides. The bedplate is also formed of transverse girders of manganese bronze bolted to fore and aft rolled steel girders. The front columns are of polished steel, and are well stayed both fore and aft and athwartships. Manganese bronze has been extensively used in connection with the various parts where cast steel is usually employed, in addition to the bedplate and frames above mentioned. This change in design is said to have given most satisfactory results. Piston valves of light design are used throughout, being actuated by double eccentric link motion. The links are of the slot type as shown. The valve gear is controlled by a single cylinder steam reversing engine, in addition to the usual hand reversing gear. The air pumps are placed forward of the main condenser, and are worked by means of a crank driven by a connection with the foremost end of the engine crankshaft, and a return connecting rod to a crosshead fitted to the two pump rods.

The condensers are cylindrical in form, and are built of thin sheet brass. They are placed in the wings of the engine rooms as low down as practicable. The circulating water is forced through them by means of centrifugal pumps, assisted by external scoops, which are so efficient as to render the services of the pumps almost unnecessary when the vessels are steaming at a high speed. The crankshafts, as well as the straight shafting, are of hollow steel. Balance weights have been fitted to the crank arms with a view to reduce the vibration of the engines.

The boilers are eight in number, and are of the Yarrow type. Four are placed in each of two boiler rooms, which are separated by a watertight bulkhead. The feed water is supplied to each boiler by an independent direct acting duplex Worthington pump. In addition to the four main pumps in each boiler room, an auxiliary pump is fitted which is capable of feeding any one or all of the boilers through the auxiliary service. These pumps are also arranged to deliver through the fire service on deck. This arrangement for feeding the boilers is reported to have worked in a very satisfactory manner, no difficulty having been experienced throughout in maintaining a steady level of water in the boiler, in spite of the fact that no automatic feed regulating gear was fitted.

The forced draught is supplied by two Belliss' fans, driven by independent engines fitted in each stokehold. The air from them reaches the fires by way of orifices in a screen built across the boiler room, and guarded by automatic flaps. The latter are designed to obviate danger in the stokehold through flames caused by back draught, in turn the result of the bursting of a tube or some other cause. The boilers were designed for a working pressure of 185 lb. per sq. in., and this pressure was maintained with a moderate air pressure in the stokehold throughout the official high speed trials.

The following are results of observations obtained on the three hours' and measured mile official trials conducted at the mouth of the Thames, the results given being the mean of the means for the port and starboard engines for the whole three hours' run:

FORCED DRAUGHT TRIALS.

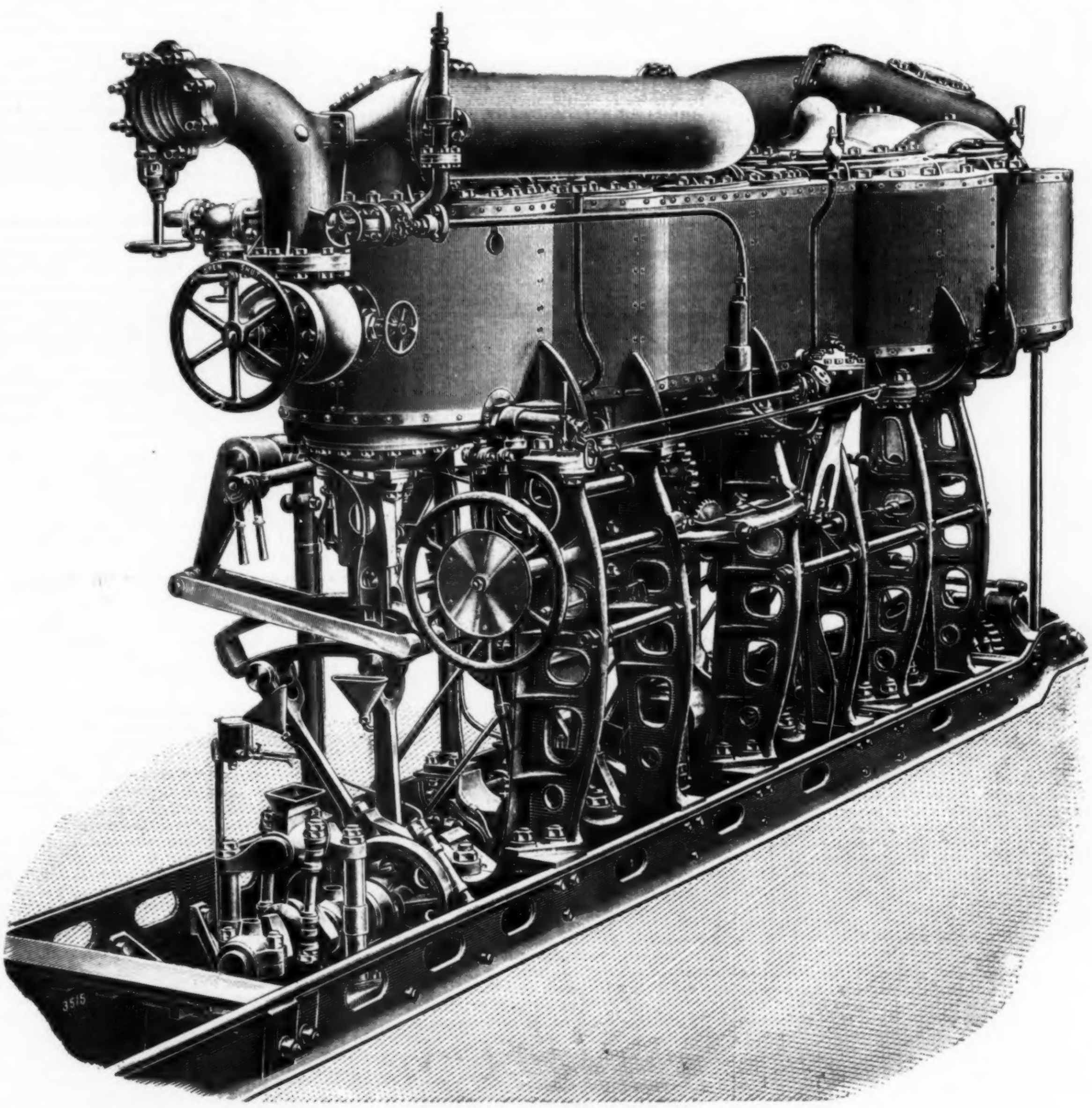
	Salmon.	Snapper.
Air pressure	2·63 in.	2·66 in.
Steam at engines	177 lb.	180 lb.
Vacuum	24 in.	25 in.
Indicated horse power.	3,628	3,699
Speed	27·608 knots	27·56 knots
Mean speed attained for six runs on the measured mile	27·88 knots	27·908 knots
Maximum speed for any pair of miles	28·07 knots	28·0 knots

A satisfactory feature of these trials was the low power required to give the speed. Careful observations which were made are reported to have shown that the wave formation was remarkably slight, and the alteration of trim between the vessels being at rest and at the high speed was unimportant, the squatting frequently observed in vessels of this class being scarcely noticeable. The propellers used were three-bladed, the blades being separate Stone's bronze castings secured to cast steel bosses by means of a special arrangement of wedges and bolts. It may be remarked that the propellers used on the successful trials were those originally designed, no alteration having been found necessary or desirable.

The following are the reported results of the twelve hours' consumption trial of the Snapper:

Air pressure in stokehold	0·35 in.
Vacuum	25·14 "
Indicated horse power	491
Speed in knots	12·984
Consumption of coal per indicated horse power per hour	1·8 lb.

This trial took place in the passage from the builders' yard on the Humber to Chatham, at which dockyard the vessels were delivered, four boilers only being under steam throughout the run. In addition to the forced draught and consumption trials above mentioned, a series of trials were made to test the maneuvering capabilities of the vessels. They were steamed ahead and astern with the rudder hard over, the former at full and the latter at three-quarters speed. These trials were concluded without the least hitch. The usual stopping and starting trials were also made, the time occupied when the engines were going full speed ahead to bring them to full speed astern being six seconds. This is a satisfactory performance, especially in view of the fact that the vacuum in the condensers was destroyed through a misunderstanding, an attendant opening one of the cocks on the condensers at the same time that the order to go astern was received in the engine room.



ENGINES OF H. M. TORPEDO BOAT DESTROYERS SALMON AND SNAPPER.

At a manufactory in Baden for agricultural machinery the practice has been adopted that when any improvements or any labor saving machines are introduced, the men's wages are not regulated so as only to leave them the same pay as before, but, as a rule, about half the profits arising out of the improvements are given to the men. This arrangement has proved very satisfactory, inasmuch as it induces the men to do their utmost and to tax their own ingenuity and intellect, to the joint advantage of themselves and their employers. In addition to this, the new system has made it possible to reduce the number of men by as much as twenty per cent.

ENGINEERING NOTES.

The Rockefeller steamer Robert Fulton, 440 feet over all, is the largest steamer on the Great Lakes.

Steamship building on the Clyde has taken a boom of late. One Glasgow firm recently received an order for fourteen steamers of from 4,000 to 6,000 tons, and nine other steamers were ordered the same week.

A street in Terre Haute was paved with brick five years ago, the joints being grouted up. The work was done partly during the winter, being finished in early spring. The foundation consisted of broken stone 7 in. thick, above which was a layer of sand 2 in. thick. At the end of July, with the thermometer standing at about 100° F., a section of the pavement rose like an arch from its foundation, and though water was turned on to it, and openings made to let out any possible accumulation of gas beneath, it maintained its position unaffected. Men were put to work to repair the pavement, but hardly had they removed the swollen section when, with a loud report, another section of the pavement rose in a similar manner to a height of 7 in. to 8 in.

The London Railway News, in an article on the British railway system, gives the following figures showing the length of railways, and their cost, together with the business done last year:

Miles of railways	21,174
Capital cost	£1,114,686,000
Passengers carried	929,770,000
Tons of minerals carried	240,365,000
Tons of goods carried	93,865,000
Miles traveled by trains	338,851,000
Receipts from passengers	£37,361,000
Receipts from freight	£44,034,000
Working expenses	£47,876,000
Number of locomotives	18,658
Number of vehicles	677,000

According to an official organ of the Russian government, says The Engineer, the iron and steel industry has taken the lead in the march of industrial progress. In 1892 only five companies, with a total capital stock of 6,000,000 roubles, were organized; in 1893, eight companies, with a capital stock of 16,800,000 roubles; in 1894, ten companies, with a capital stock of 13,250,000 roubles; in the first half of 1895, three companies, with a capital stock of 4,830,000 roubles, but in the second half of 1895 there were organized eighteen companies, with a capital stock of 60,580,000 roubles, and in the first half of 1896 twenty-three companies, with a capital stock of 83,337,500 roubles. The enlargement of capital stock of existing corporations aggregated in 1892, 3,300,000 roubles; in 1893, 3,550,000; in 1894, 12,550,000 roubles; in 1895, 22,087,500 roubles; and in the first half of 1896, even 24,885,000 roubles.

Through trains over the Brooklyn Bridge, connecting with the elevated railways and street car lines on either side, were considered at the meeting of the bridge trustees, October 26. Mr. Wurster, mayor of Brooklyn, spoke strongly in favor of some definite steps being adopted instead of continually postponing consideration of the question. It was eventually decided to employ three engineers, who, together with Mr. C. C. Martin, the chief engineer, will form a board of engineers to examine the bridge and settle once for all the feasibility of through and continuous traffic; the sum of $3,000 was ordered appropriated for this purpose. Two engineers are to be selected by the mayors of the two cities, and the third one by the vice-president or president of the board of trustees. Mr. Howell, the president, has appointed Mr. L. L. Buck, M. Am. Soc. C. E., who is chief engineer of the new East River bridge.

An East River tunnel railway to connect New York and Brooklyn is now proposed by the New York & Brooklyn Railway Company, says the Engineering News. The tunnel tracks are to come to the surface at each end, to afford direct connection with other lines. The proposed tunnel is to run from the junction of Myrtle and Willoughby Avenues, Brooklyn, across the East River, in almost a straight line, parallel to the Brooklyn Bridge, to the New York terminus, at Park Row and Ann Street. It will be lighted by electricity. The general plan is to have two tracks in two tunnels, thus making a four track line. These tunnels will be 8,700 feet long, and the two tunnels together will be 45 feet wide. The grade at either end will not be more than 4 per cent. This is the project which has been brought forward from time to time by Mr. B. S. Henning, who is president of the company. The directors include Emerson McMillin; Silas B. Dutcher, president of the Hamilton Trust Company, of Brooklyn; J. N. Partridge, president of the Brooklyn City & Newtown Railway; Henry W. Slocum, former president of the Coney Island & Brooklyn Railway; and James C. Church, secretary of the Nassau Electric Railway.

Many years ago an engine, built by Corliss, was set up in a rolling mill in one of the Western American cities. It was, in several respects, an exceptional engine, different in a number of particulars from the regular Corliss design, and has only once or twice been duplicated. After running for four or five years, it was taken down and erected in another city, and the engineer in charge found that one of the dashpots needed renewing. An order was at once sent to Mr. Corliss for the dashpot castings in order to fit up a new set. In due time there arrived by express a box, and the engineer, on opening it, found, much to his indignation, instead of the castings, a dashpot, bored out, bolt holes drilled, seat faced off, and everything finished, ready for putting on to the engine. His first impulse was to consign the thing to the scrap heap and order another casting, for, as he remarked, "Any fool should have known better than to send a finished pot 1,500 miles with the expectation of its fitting an old engine." However, the thought occurred that there might possibly be metal enough in the flanges to enable new holes to be bored, and he, therefore, concluded to try the thing in its place, and was much astonished to find that it went on just where it belonged, with bore and bolt holes coming exactly in line. That was at a time when interchangeability of parts in machinery was not so common as it is now and when its existence in connection with small details might well have been a matter of wondering comment.—Cassier's Magazine.

ELECTRICAL NOTES.

Prof. Roentgen has received a copy of the Thompson & Anthony book on X rays, and writes that he has read it with great interest.

Paris policemen have been supplied with electric dark lanterns, by means of which they can see 150 feet away. They were employed successfully in a recent raid in the Bois de Boulogne on the homeless persons who sleep there at night.

The post office in London has pneumagrams for its own use and convenience, but this system of sending short messages is not open to the public; although as "Lightning" observes, messages might be sent by the existing pneumatic tubes at a cheaper rate than by telegraph, and it would pay the post office a handsome profit. The system might be adopted in all large towns and extended enormously in London. It has been long in operation in Paris and Berlin.

A correspondent of the London City Press writes as follows: "In the Philosophical Transactions of 1769 there was made a proposal for a method to secure St. Paul's from fire 'by means of electrical conductors, fixed up in a manner that is now generally known.' Perhaps a reader can inform me whether these electrical conductors were affixed to the cathedral at this time, and if so, what was their nature, and whether they still do duty? It would be interesting to learn which was the first city building furnished with lightning conductors."

Compared with other large European towns, says an exchange, London is easily at the head for the magnitude of its electrical supply. Paris, for instance, has only an equivalent of about 500,000 eight candle power lamps as compared with the 1,300,000 lamps in London. Manchester and Liverpool have respectively about 92,000 and 54,000; Glasgow, 70,000; Edinburgh, 43,000; Dublin, 16,000; and Cardiff, 9,000. Of the total capital expended in the whole of the United Kingdom for supplying electricity, London has expended more than one-half.

J. J. Reifgraber, of St. Louis, Mo., has invented and patented an apparatus by which typographical composition can be simultaneously reproduced electrically in as many newspaper offices as are connected with the transmitting wire. The device is apparently a combined typewriter and perforating machine, by which the operator not only prints the respective characters represented by the various keys, but produces a strip of paper upon which are perforations for every key depressed. This perforated slip is inserted in an electrical transmitter, and through identical machines at other and distant points this perforated slip is inserted into another little instrument attached to the Mergenthaler linotype machine, thereby automatically operating the same and setting up the matter in type. Any number of similar instruments may be connected with the same wire, at various cities and towns, and all will do the same work at the same time.

Waldenburg, in Silesia, has made a very favorable contract for the building of an electric power and light plant. The company is allowed to place wires in all the streets of the town for fifty years, but this right is exclusive for twenty-five years only. The light plant must be in working order on or before April 1, 1898, and a fine of $25 will be paid for each week that the completion is late. The company agrees to light the streets with eighteen arc lamps and one hundred and ten incandescent lamps, free of charge, for twenty-five years at least, and as long as no concession is granted to other concerns. The company agrees to pay the regular town taxes, but will not have to pay any special taxes on the consumption of current as long as its monopoly lasts. Furthermore, the company has to build electric roads from Waldenburg to three neighboring localities within three years.—Elektrotechnische Rundschau.

Some interesting experiments have recently been conducted by A. Hagenbach, in the Annalen der Physik und Chemie, on the subject of thermo-elements composed of amalgams and electrolytes. He determined the thermo-electromotive force for elements, consisting of the following chain: Cadmium amalgam | solution of a cadmium salt | cadmium amalgam, and of a similar chain for lead. The sulphate, nitrate, chloride, bromide, and iodide of cadmium, and the nitrate and chloride of lead were employed at various concentrations. One electrode was maintained at a temperature of about 6°, and readings taken with the second electrode at temperatures ranging from 6° to 80°. The thermo-electromotive force was found to be approximately proportional to the temperature, except for lead chloride, where it remained almost constant from 30° to 50°, while, contrary to expectation, the E. M. F. decreases with increasing dilution, the decrease varying with the different salts. The original paper may be found in the Annalen der Physik und Chemie, 1896 (2), No. 58, p. 21 to 36.

At a meeting of the Engineers' Club of Philadelphia, Saturday evening, October, 17, Dr. H. M. Chance described, says the Colliery Engineer, the application of electricity to the extraction of gold from the ores or materials with which it is associated. The processes described differ widely, both in method and principle, and were described as consisting of six classes, each involving a different principle or method of application. These classes are: 1, Electro-magnetic; 2, electro-solvent; 3, electro-amalgamating; 4, electro-precipitating; 5, electro-inductional; 6, electro-smelting.

The first class employs electro-magnets to remove magnetic material from the gold with which it is associated or mixed. In the second class the current is used to assist in dissolving the gold from ores by means of chemical solvents of gold. In the third class the current is passed through the amalgamated plates or mercury to facilitate amalgamation. The processes of the fourth class are electrolytic, the gold being electrically deposited from its chemical solutions. These processes are extensively used in South Africa, and to some extent in this country. The fifth method aims to remove gold particles from other materials by the inductive action of high-frequency alternating currents. The sixth method, that of electric smelting, promises well, provided the cost can be reduced to that of ordinary smelting processes.

MISCELLANEOUS NOTES.

New industrial companies, capitalized at $50,500,000, were advertised in one day's issue of the London dailies recently.

Paris has found it necessary to put a check to the haphazard decoration of her public places. The prefect of the Seine has appointed a technical committee of artists, architects, and other competent judges, to which all plans affecting the outward appearance of the city must be submitted for approval before the administrative officers take them up.

Speaking of a current item that magnifies the dangers of licking postage stamps, the National Druggist says: "That the habit of licking stamps is one not to be commended all will grant. It is not cleanly, to say the least, and that it might, under certain circumstances, be a possible source of contagion or infection, may be admitted; but when one takes into consideration the millions and millions of times that it has been done without furnishing a single well authenticated instance, that we are aware of, where disease has been directly traced to it, we think that we are fairly entitled to call the 'scare item' a mere bacteriological mare's nest."

The Paris Union for Moral Action proposes putting on all the dead walls and bill boards of the city posters which shall suggest desirable and elevating trains of thought. This idea originated with Paul Desjardins, who is the present reigning moralist, and he will begin at once with lithographs of the frescoes of M. Puvis de Chavannes, representing scenes in the life of St. Genevieve, who saved Paris from Attila the Hun. It is thought that by the influence of these pictures (executed in two colors) the inhabitants of the French capital will be brought to the ways of virtue. It is safe to say, however, that, if the posters are not artistically beautiful, they are likely to excite more criticism than morality.

A New Incandescent Gas Mantle.—A new incandescent gas mantle has been produced by M. Ladureau. It consists of organic threads which are impregnated with metallic oxides. The light radiating apparatus consists of two platinum wires around which the illuminating threads are wrapped in such a manner as to stand upon the wirelike hair in a brush. They are not fragile, so they can be handled with safety. When in use they become more fragile. They become more durable, it is said, the longer they burn. With this apparatus M. Ladureau has obtained on a single one of these threads a light effect 1½ centimeters wide and 7 or 8 centimeters in length. The consumption of gas is thus considerably lessened.

James C. Monoghan, United States consul at Chemnitz, Germany, is in Washington in consultation with the State Department officers respecting the best means for bringing to the attention of American merchants the advantages of the new German method of technical education of young men selected for the purpose of traveling abroad and placing German goods in foreign markets. The system has had such results in Germany as to secure the attention of British exporters, who find themselves crowded out of many of their old and lucrative markets by the German salesmen and agents. Mr. Monoghan is desirous of laying the plan before our merchants and manufacturers in the hope of inducing a movement to install the system in the United States.

An eating house made of paper has been erected in the port of Hamburg. Its walls are composed of a double layer of paper stretched on frames and impregnated with a fire and waterproof solution. A thin wooden partition affords further protection against the inclemency of the weather. The roofs and walls are fastened together by means of bolts and hinges, so that the entire structure may be rapidly taken to pieces and put up again. The dining room itself measures thirty by six meters, and is capable of accommodating 150 persons. There are twenty-two windows and four skylights, and the heating is effected by a couple of isolated stoves. A side erection contains the manager's offices, kitchen, larder and dwelling rooms. The total cost of the construction is said to have amounted to 1,500 marks.

Notice appears in London Invention of a peculiar product, under the name of soap stock, prepared in Brindisi, which is largely utilized on account of its special properties. It is prepared by subjecting the residue of olive kernels to chemical processes under the action of sulphuric acid, after all means of extraction by pressure have been exhausted. Of this substance it is stated that during the year 1894 the quantity produced amounted to about 1,200 tons, the medium market price for which ranged at some $90 per ton. The article in question, which is of little value as a lubricator, has a ready sale among soap manufacturers, and in years when the oil crop has been favorable considerable quantities have been exported to this country, Great Britain and northern Europe. This oil is locally known as "olio sulfureo," or sulphur oil, from the method of its extraction. The refuse remaining after the extraction is used for fuel for steam boilers by millers as a matter of economy.

Fortschritte der Industrie states that the production of beads from aluminum has not been accomplished with entire success so far, on account of the softness and porosity of this metal. The present punching machines used for this purpose have the fault that by reason of their too great stability they tear the aluminum plate to be shaped, instead of forming it into a sphere, or that, although bending the plate together, they deform it so that no sphere shaped body is produced. Winterburg & Eisner, of Gablonz, Bohemia, have succeeded in producing perfectly shaped aluminum beads by means of an apparatus invented and patented by them. The top of the punch consists of two parts, connected by a spring, and provided with a pin for perforating the bead. The aluminum plate is first fixed and punched out by the apparatus, then pressed into a correct sphere and perforated by a quick, sharp blow, which causes the spring to recede. The apparatus is simply constructed, but very efficient, and it is expected that it will soon be used generally in the manufacture of aluminum beads.

SELECTED FORMULÆ.

To preserve ink, add from 0·1 to 0·2 gramme of salicylic acid to 1 liter of ink.

Black Inks for Rubber Stamps.—The Bayerische Indust. und Gewerbeblatt gives the following. For general use:

Tannin, black	1 part.
Water	1 "
Glycerin	2 "

Mix.

For textile fabrics the following is recommended:

Nigrosin	2 parts.
Methyl violet	4 "
Water	5 "
Wood vinegar	5 "
Alcohol	5 "
Glycerin	35 "

Mix and dissolve. —National Druggist.

Restoring Tarnished Gold.—According to the Jeweler's Circular, the following mixture is an excellent one for restoring gold which has become tarnished:

Sodium bicarbonate	20 ounces.
Chlorinated lime	1 "
Common salt	1 "
Water	16 "

Mix well and apply with a soft brush. A very small quantity of the solution is sufficient for effecting the desired purpose, and it may be used either cold or lukewarm. Plain articles may be brightened equal to new by putting a spot or two of the liquid upon them from the stopper of the bottle and lightly brushing over the surface with a fine tissue paper until sufficiently dried off to accomplish the object intended.

Crab Apple Blossom.—A very satisfactory essence can be prepared by the following formula:

Ess. ambergris	1 ounce.
Ess. musk	3 "
Spirit of rose	16 "
Ext. cassie	10 "
Ext. tuberose	10 "
Ext. jasmine	10 "
Ext. violet	1 pint.
Ext. rose	2 "

Mix and store for a few weeks before decanting.

Benzin Emulsion, a Soap Milk for Cleansing.—

Benzin	500 grammes.
Powdered soap	3 "

Distilled water, q. s. to make perfect emulsion.

The soap is dissolved in 50 to 60 grammes of lukewarm distilled water, placed in a two liter flask, and shaken up. Then add, portion by portion, the benzin, and continue to shake vigorously for a long period. If half of the benzin has been added by fractions, and on continued shaking there is no perceptible emulsification, the latter can be achieved by immersing the whole bottle in a warm water bath; or, better still, pour 50 to 100 grammes of water, temperature of 60° to 80° C., into the benzin, and shake well a number of times. After the emulsification is complete, add by portions the other half of the benzin and shake well several times.

Three grammes of soap is sufficient to emulsify 1,060 grammes of benzin, and this amount of soap may be reduced if warm water be added, by small quantities, to the finished emulsion; the emulsion becomes thicker and will now stand a larger quantity of benzin. It is possible to produce an emulsion so rich in hydrocarbons that for 1,500 grammes benzin only 3 grammes soap, besides a smaller quantity of water, is needed.

The finished emulsion should be permitted to stand quietly for several days; during this time the water not required by the emulsion separates out and collects at the bottom of the flask.—Montreal Pharmaceutical Journal.

To Preserve Rubber.—To prevent rubber tubes from becoming dry and brittle, coat the tubes with a 3 per cent. aqueous solution of carbolic acid, and it will also preserve them. To render them soft again after once having become brittle and stiff, place them in ammonia diluted with twice its volume of water.

Test for Formic Aldehyde.—As the result of a special examination of the methods of testing for minute quantities of formic aldehyde, Dr. Lebbin finds that a very excellent result may be obtained by means of the red colored condensation product formed with resorcin. To a few cubic centimeters of a solution containing formic aldehyde, some resorcin (about 0·05 gramme) is added with about an equal volume of caustic soda (50 per cent.) and the mixture heated to boiling. The yellowish color first assumed then becomes deep red, and is permanent. This reaction does not appear to take place with other bodies besides formic aldehyde, and, according to Dr. Lebbin, the test may be relied upon for detecting the presence of formic aldehyde in ten million parts of water. In the proportion of one millionth the indication is very marked, and a volumetric method of quantitative determination may be adopted. —Pharm. Zeitung.

Unfermented Wine.—Prof. Müller, of Torgau, Switzerland, has applied the principle of Pasteur's treatment of wine for the preservation of grape juice and other fruit juices without fermentation. He finds that when the freshly expressed juice is heated in bottles to a temperature of from 60° to 70° C. for fifteen minutes, the yeast cells and other fermenting agents are rendered inactive. The juice can then be kept in well closed bottles for several years without fermenting. To obtain the juice clear, it must, however, be filtered, an operation which is easily carried out, as the heating will have coagulated the mucilaginous substances causing turbidity. Filtration may be carried out immediately after heating the juice, or after some time, but in any case the filtered juice must be again heated in bottles to the temperature originally applied, and then it will keep clear in well closed bottles for several years. Some grape juice bottled in this manner in 1882 is still sound and unfermented. A Swiss company has been formed to manufacture unfermented grape and fruit juices in this way during the present autumn, and it is expected that the products will meet with a large demand among advocates of temperance and as agreeable dietetic beverages for invalids.—Pharmaceutical Journal.

THE BOYER AUTOMATIC SUSPENSION HOOK.

AMONG the methods employed up to the present for suspending or supporting various objects, whatever be their weight, in the installation of offices, stores, workshops, and apartments, there is certainly none that is as practical as the system devised by M. J. M. Boyer, of Paris. It is an ingenious application of the eccentric to the fixing of hooks, brackets and rings, and, in fact, of all kinds of pieces capable of supporting any sort of weight, along wooden or metallic rods of various forms (Fig. 2).

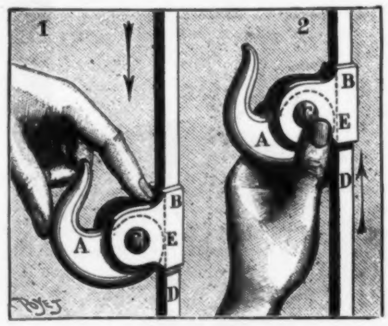


FIG. 1.—METHOD OF RAISING AND LOWERING THE ECCENTRIC HOOK.

Each piece of the device is provided with an eccentric hook, A, held by a slider, B, through a rivet, C. When an object is suspended from the hook, its weight, in exerting a pressure upon the eccentric, causes the slider to clasp the rod tightly at E (Fig. 1). The heavier the weight the closer the embrace, so that sliding becomes impossible.

The displacements of these apparatus are easy, and are effected as follows:

(1) To move one of them upward, the slider is grasped at C, between the thumb and forefinger, and simply raised. (2) To cause the same to descend, a slight pressure is exerted upon the eccentric with the forefinger at B, while the thumb bears against the hook at A.

The extreme facility with which the Boyer apparatus move in all directions renders their manipulation easy to everybody. With the use of them there is no fear, for example, of the fall of a glass or wooden shelf in a show window, as so frequently happens when one has forgotten to tighten the binding screw, or when the latter is worn or works loose for some reason or other and allows the support to slide, with disastrous results to the articles displayed.

As another example, we may mention very heavy pictures, the cords of which sometimes break and pull out the nails from which they are suspended against a wall. The application of the eccentric in such cases has permitted the inventor to revolutionize, in a manner, the former way of doing things, since the use of the principle may be varied to infinity.

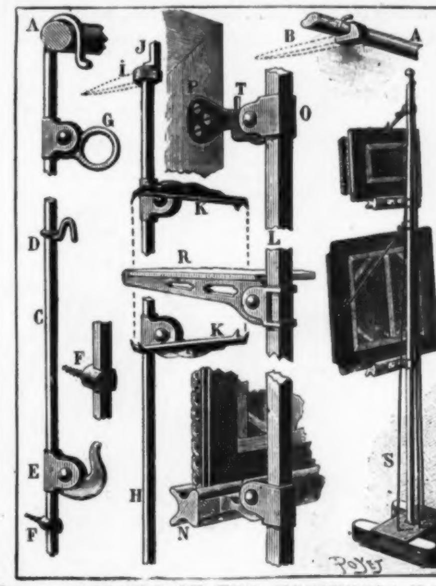


FIG. 2.—DETAILS OF THE ECCENTRIC HOOK.

A, hollow or solid rod; B, nail for supporting A; C, steel rod with hook sliding upon A; D, picture hook; E, eccentric hook; F, leveling screw; G, ring support for movable rods; H, another support with bayonet catch, J; I, wrought iron nail supporting the rod, H; K, special supports for frames; L, steel rod for heavy pictures; N M, support for framed pictures; P, hinge screwed to the back of the frame; R, support for displaying pictures; S, easel.

In Fig. 3 we give a rear view of a collection of paint-

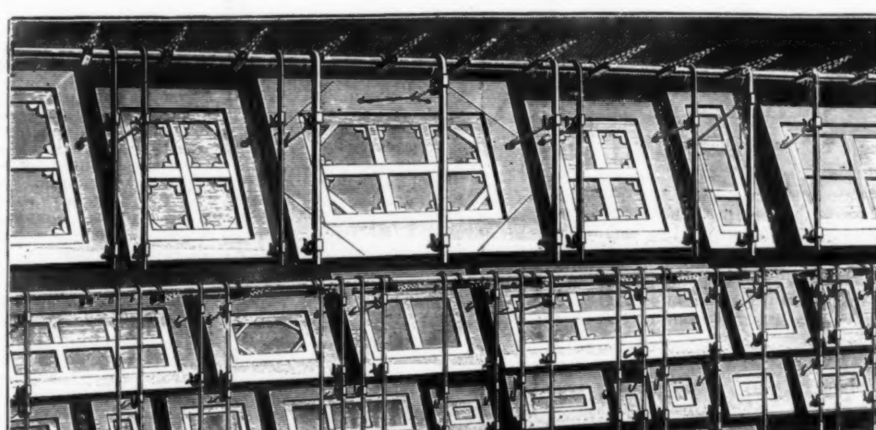


FIG. 3.—METHOD OF HANGING PAINTINGS.

FIG. 4.—ARRANGEMENT FOR EXHIBITING PICTURES FOR SALE.

ings, showing the mode of suspension through rods, screws and eccentric hooks.

In Fig. 4 is shown an arrangement of movable supports for the exhibition of paintings, and permitting of the development of an extremely wide surface upon a relatively limited floor space.

As may be seen, the application of the apparatus here described does away with the damage done to walls and partitions by clasp nails, mirror hooks, screw rings, spikes, etc., that are used thereon for the needs of one's trade, and that are useless after being extracted from the plaster.—La Nature.

OIL TRACTION ENGINES AND LOCOMOTIVES.

WE illustrate herewith two new adaptations of the Hornsby-Akroyd oil engines, which are of interest in showing how advantageously the smaller classes of portable and locomotive steam engines can be replaced by oil motors. The oil traction engine shown in Fig. 1 is a specimen of the smallest size made, being capable of hauling 20 to 25 tons along good roads on the level, 8 to 10 tons up an incline of 1 in 16, and 6 to 7 tons up an 8½ per cent. grade. It is, moreover, sufficiently powerful to drive a 4 ft. 6 in. thrashing machine, with its straw trusser or elevator. As will be seen from our engraving, the engine is mounted on an iron or steel framing. By means of gearing it can be run at three different speeds, all the wheels involved being steel castings. The main axle is fitted with compensating gear, so that sharp turns can be taken without casting loose one of the driving wheels, while an efficient brake prevents the possibility of the engine running away. The oil tank will hold about 1½ days' supply of oil, and, as only about 60 gallons of water are required for cooling purposes, the man and horse usually required to haul water for a steam engine of similar capacity can be practically dispensed with. Further, no coal has to be loaded, the oil used instead being much more easily handled, and a single barrel holding 400 lb. will suffice to run the engine shown for about three days. Special arrangements have been made to silence the exhaust, which is sometimes painfully emphatic in the case of explosion engines. On the road the driver's duties are much less trying than in the case of a steam engine. There are no water or steam gages to be looked after, nor fire needing constant attention, so that one man is quite capable of looking after the machinery unaided. Four sizes of the engine are made, the largest being about double the power of that to which our illustration refers.

The engine shown in Fig. 2 was constructed for the Woolwich Arsenal, where a locomotive was required with which there would be no danger of sparks escaping with the exhaust gases from the funnel. Like the traction engine previously described, this locomotive requires an extremely small supply of water, and would accordingly appear to be well fitted for use in arid districts. The work of running the engine being so much less than in the case of a steam locomotive, one man suffices to run it, the stoker's services being dispensed with. The reversing gear is of the clutch type, the parts being of steel. Springs are fitted as usual in locomotives, and all the necessary accessories are supplied. It will, however, be seen that buffers have been omitted, since the arsenal authorities wished to fit these themselves. One advantage of these engines, as compared with steam motors, is the rapidity with which they can be started when cold, 15 minutes being sufficient for this.

The engines illustrated were built at the Spittlegate Iron Works of Messrs. R. Hornsby & Sons, Limited, Grantham, London.—Engineering.

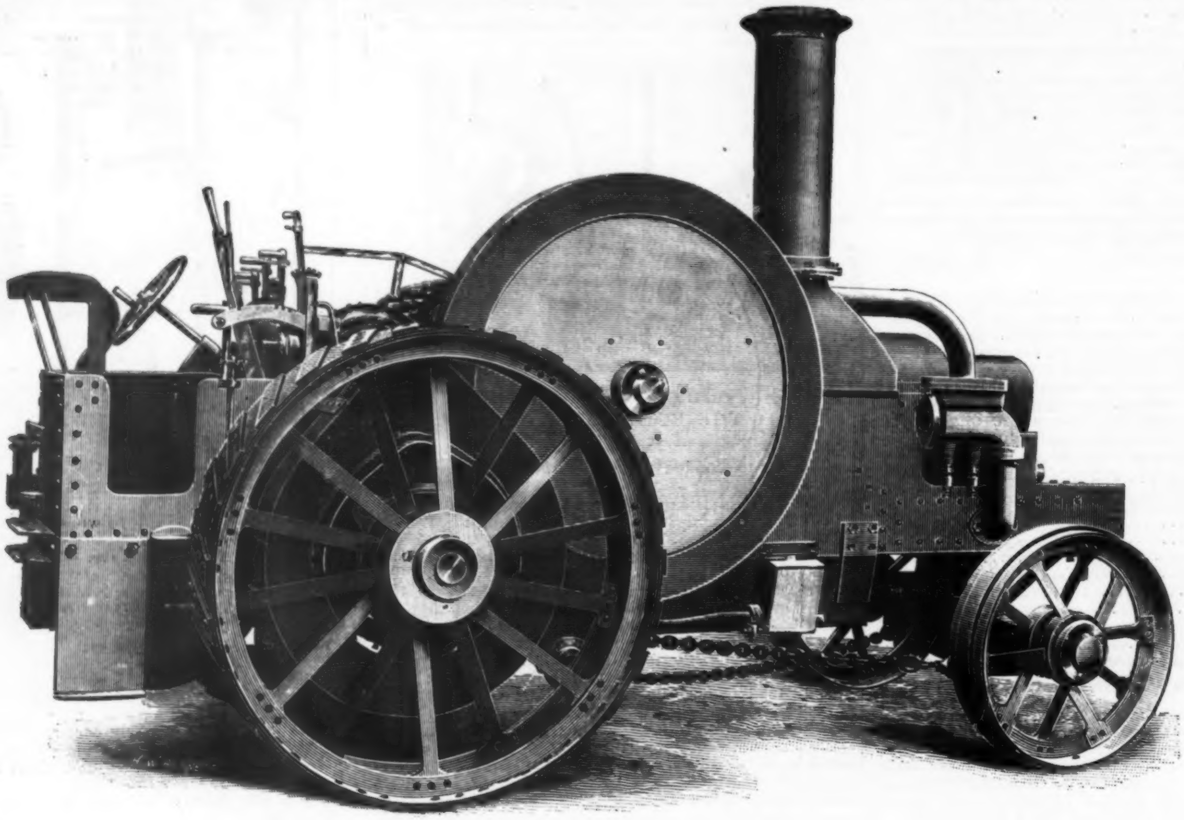


FIG. 1.

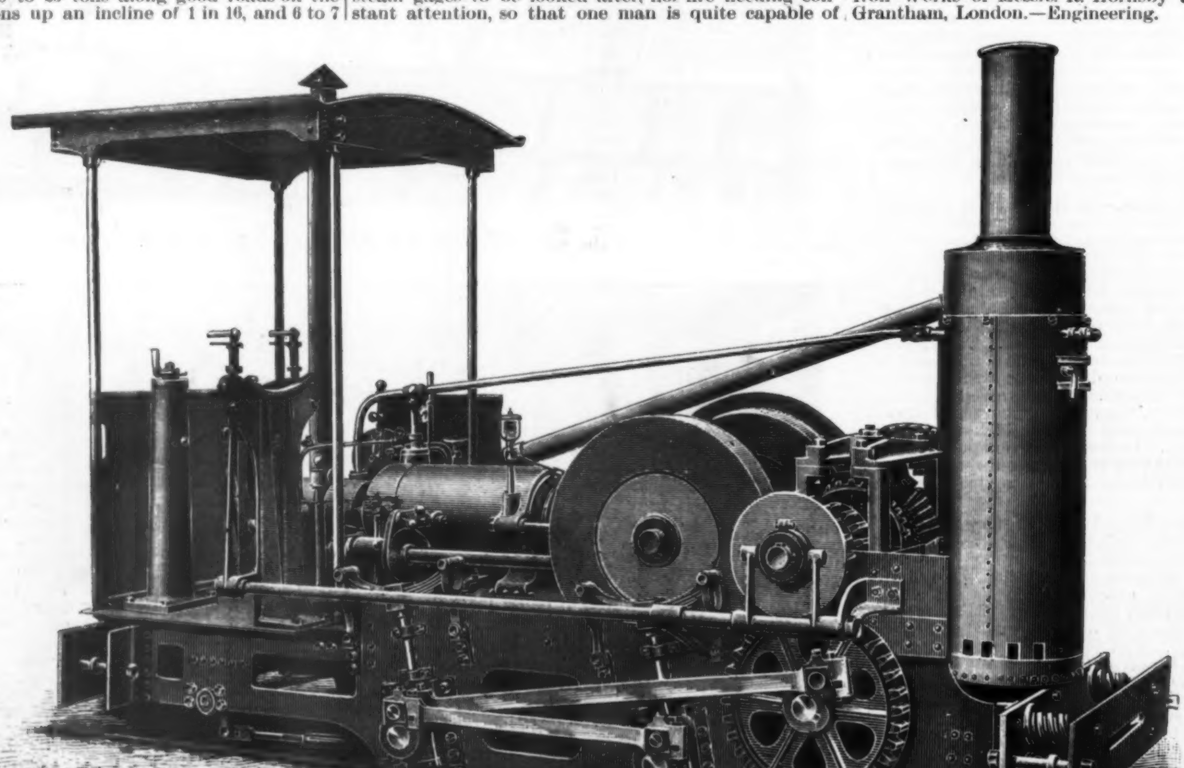
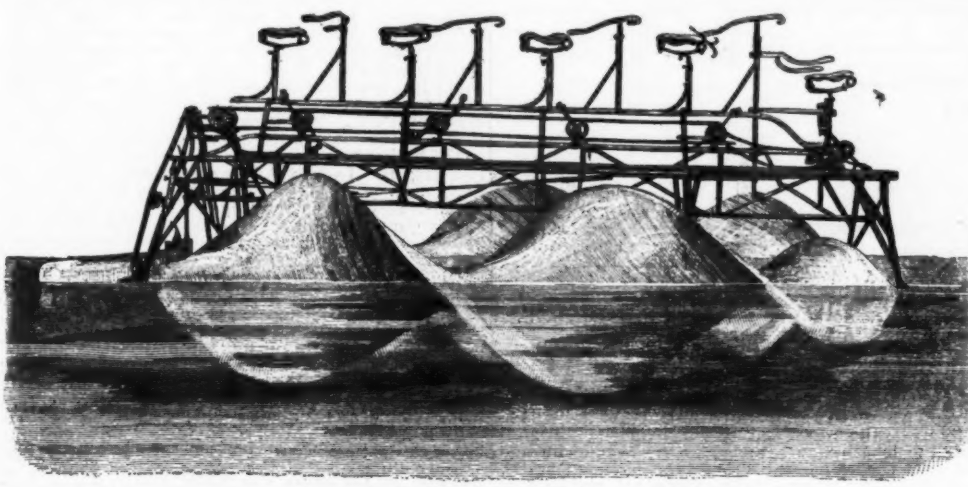


FIG. 2.

OIL MOTOR TRACTION ENGINE AND LOCOMOTIVE.

BREYER'S WATER VELOCIPEDE.

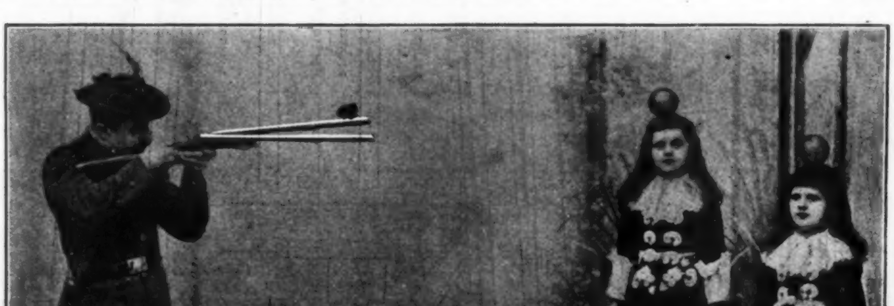
WATER velocipedes have been constructed by different inventors, but none of them appears to have given satisfactory results. Still improvement is noticeable, in the later designs, and, as in the history of steamships, a great advance has been made by substituting screw propellers for the paddle wheels used originally. A peculiar kind of water velocipedes has been invented and repeatedly improved by Herr Breyer, and the latest development of this invention is shown in the cut. The propellers are hollow to give them sufficient buoyancy, since they are intended to carry the whole structure with the occupants. In a velocipede with four seats, two screw propellers are provided. Each of them is partitioned so that injury to the shell of the propeller will not cause sinking of the velocipede. The axis of the propeller is level with the surface of the water. The center of gravity is very low, so that capsizing is almost impossible. The propellers cut very easily through water and air and little power is required to rotate them. Their action is different from that of a ship's propeller in that their inner portions, near the axis, have a considerable driving effect, while with a ship's propeller nearly all the work is done by the outer ends of the blades. The length of the screw propellers, including their tapered ends, is about 5½ yards. Each revolution of the propeller produces a forward movement of about 4 yards. With forty-five pedal strokes a minute and a gear of one to two between propeller shaft and pedal shaft a speed of about 13 miles would be obtained. It has also been attempted to apply the same type of propellers to water velocipedes driven by a motor.—Illustrirte Zeitung.



BREYER'S WATER VELOCIPEDE.

THE SCURIMOBILE.

THE peculiar gun shown in the cut is named after its inventor, Alessandro Scuri, of Liege, Belgium. Mr. Scuri is also known as the inventor of a unicycle and a quadruple cornet. The scurimobile is a gun with two barrels which can be aimed at different objects, the angle between the barrels being adjustable. The adjustment is effected by moving a ring located on the under side of the gun. The pivot of the barrels is so arranged that it is easy to sight two objects at the same time. Both cartridges are automatically ejected after each shot fired. It is also possible to use only one barrel in the ordinary way. In the cut the inventor is shown aiming at two balls placed about a yard apart. Another valuable feature of this new gun is its applicability as a range finder. The observer first sights two objects which are at about equal distances from him, and measures the distance or angle between the two barrels, a graduation being provided for this purpose. Then the same operation is made from a point more distant from the objects first sighted. If the observer steps back ten yards, and finds that the graduation indicates just one-half of the value obtained at first, he will know that in the second position he was just twice as far from the objects as in the first position, so that the objects are ten yards from the observer's first position. This operation will give distances with sufficient accuracy in most cases, but more exact results can be obtained by means of a simple trigonometric formula when the angle between the barrels is measured. The inventor is now engaged in applying the same principle of construction to pistols, hunting rifles and repeating guns. The gun illustrated is sold at $15.—Illustrirte Zeitung.



THE SCURIMOBILE.

APPARATUS FOR ELIMINATING VIBRATION FROM THE SUPPORTS OF DELICATE INSTRUMENTS.

PROF. W. H. JULIUS, of Amsterdam, has devised an ingenious apparatus for neutralizing the effect of the vibrations which are rarely completely absent from any available standing place or point of attachment in physical laboratories. Prof. Julius first described his method in Wied. Ann. 56, p. 151, 1895, and its principal features may be stated as follows:

1. The instrument to be protected is fastened upon a suitable stand, which is supported on three long wires. Let the points on the beam of wall bracket to which the supporting wires are attached be called A, B, C, and the corresponding points on the stand where the wires are connected, A', B', C'. It can be shown that, with this arrangement, the forces which act on the instrument are much smaller than if the stand rested directly on the points, A, B, C.

2. The center of inertia of the whole suspended system (the instrument and stand taken together) is brought to coincide with the center of the equilateral supporting triangle, A', B', C'. The great advantage of this arrangement is, that the impulses starting from the supporting points, A, B, C, and proceeding along the wires, have the least possible effect in causing rotations of the system about its center of gravity.

Such rotations would, however, be completely eliminated only when the three suspending wires are exactly identical and under the same tension, when the points, A, B, C, during the vibration, experience only simultaneous parallel displacements, and when air currents and air resistance are negligible in amount. Under these conditions the movements of all points of the body would be the same as that of the center of gravity.

Now, it is quite possible to satisfy these conditions approximately by making the whole arrangement, as far as possible, symmetrical, and by properly choosing the point of suspension; but this cannot be thoroughly carried out in practice, and the consequence is that the different points of the suspended system are subjected to disturbances proportional to their distance from the center of gravity, in addition to the displacement which they have in common with the center of gravity.

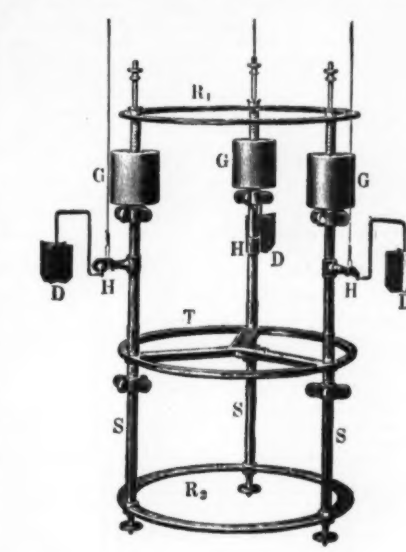
Accordingly, if there is in the instrument a special point, P, which it is desired in preference to all others to protect from the influence of vibrations, as, for instance, the point in a galvanometer to which the quartz or silk fiber of the magnet system is attached, then this is best done by bringing this point as near as possible to the center of gravity.

In his earlier apparatus Prof. Julius made no provision for making this adjustment, but in an apparatus described in the Zeit. f. Instrumentkunde, September, 1896, he shows a very simple and efficient method of carrying out this last refinement. The improved apparatus has been made by P. J. Kipp and Zonen (J. W. Giltay), of Delft, and has been found already, in several laboratories, to work very satisfactorily. This apparatus is illustrated in the accompanying figure, and may be described as follows:

Three rods, S, are screwed together by means of two rings, R_1, R_2, to form a stand. Strong hooks, H, are fixed on the rods to suspend the apparatus. The points of these hooks, where the loops of the suspending wires rest, determine the three corners of the equilateral supporting triangle, A', B', C'. Upon each rod there is a sliding lead weight, G; the rods are marked with a scale of equal parts above the hooks, H, and the weights can be fixed at any height by means of a split cone and winged nut.

A third ring, T, is mounted so that it can be displaced along the rods, and clamped at any required point by similar fly nut clamps; it forms the table plate of the stand, upon which the instrument to be protected is placed, and to which it is firmly fixed by attached clamps.

The adjustment is made as follows: The stand is set upon a table, and leveled up by means of its screw feet, the suspending wires having previously been disconnected from the hooks. The ring, T, is then fixed at such a height that the point, P, of the instrument



lies in the plane, A', B', C'. The instrument is at the same time leveled and clamped to the stand.

It is now necessary to bring the center of gravity of the whole system into the plane, A', B', C'. For this purpose the whole arrangement is turned on its side (of course after the sensitive part of the instrument has been removed), in such a manner that the hook on the left hand of the figure lies uppermost. The wings, D, by which the damping of the oscillations of the stand itself is effected, must not be screwed on till after this operation is complete. The apparatus, for the present, is suspended by the one hook, H, and the weights, G, are displaced till the rods, S, lie horizontal. Care must be taken that all the three weights are fixed at the same divisions on the scales.

When the instrument to be protected is very heavy, and its center of gravity is low, so that the movable weights are not capable of producing equilibrium, auxiliary weights can be fixed on the continuations of the rods on the other side of the ring, R_1.

After the weights have been clamped in the correct position, the stand is restored to the vertical position, and set upon its screw feet. The loops of the suspending wires are slipped on to the hooks, H; the dampers, D, which are afterward to be dipped into vessels containing paraffin oil, are then attached.

The sensitive part of the instrument is now fitted in, and the table on which the stand rests is slowly lowered, till the arrangement is left suspended on the three wires. If the level of the apparatus is at all disturbed by this operation, the wires must be shortened or lengthened at their suspension points, A, B, C. In order that this may be readily carried out, the wires are furnished with a tripod having three clamps, which is fastened by a strong screw bolt to the ceiling of the room, or better still, to a separate beam. The exact adjustment of the wires may be done once for all; the small adjustments which are necessary to allow the system to hang free are best made in the usual way, with the screw feet of the instrument; if no essential displacement of the point, P, is caused thereby. In the illustration the whole arrangement is shown, with the exception of the tripod and the three clamps for fastening on the instrument.—The Electrical Review.

MANY frescoes, some going back to the fourteenth century, have been discovered on the walls of the Church of San Floriano, at Montefiascone, during recent repairs.

SUSPENSION BRIDGES—A STUDY.*

By George S. Morison, Past President American Society Civil Engineers.

The method of demonstration and illustration which has been adopted is the explanation of the design of a suspension bridge of unusual dimensions and capacity. The size selected for this design would give a clear opening of about 3,000 ft., this corresponding to the

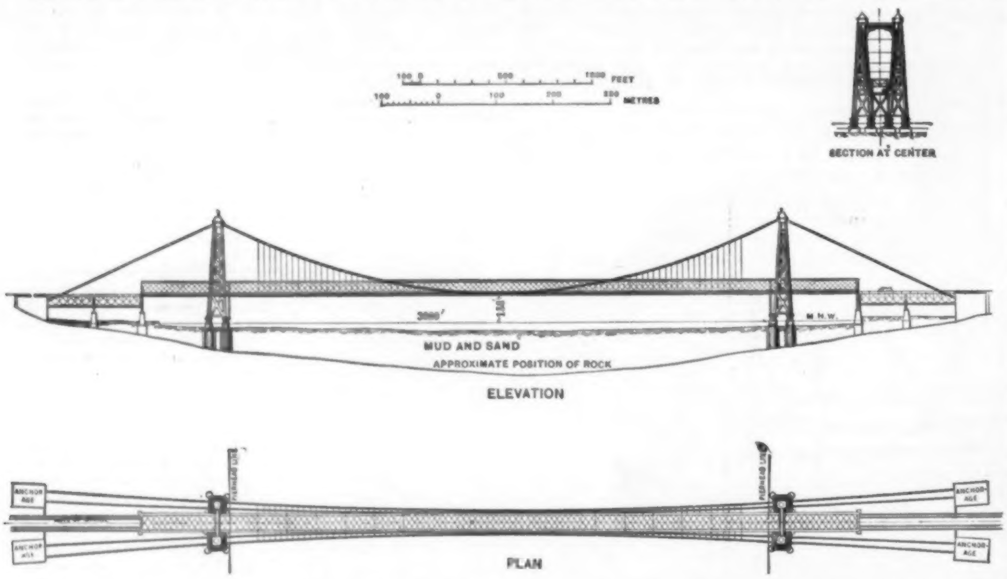


Plate I.—ELEVATION, PLAN, AND CROSS SECTION OF 3,000 FOOT SUSPENSION BRIDGE.

dimensions proposed for the North River at New York. The plan discussed is simply a general plan, but as such a discussion to be valuable must be accompanied by estimates, the depth to rock at the sites of the towers has been assumed to be 140 ft. below mean high water. It has been assumed also that the anchorages would be built on rock, and elevations have been assumed for these anchorages.

In one respect the design departs radically from suspension bridges hitherto built. The cables, instead of being made of straight wires, are made of ropes, and these ropes, instead of being passed over the towers and around pins in the anchorages, are socketed, both at the top of the towers and in the anchorages, all con-

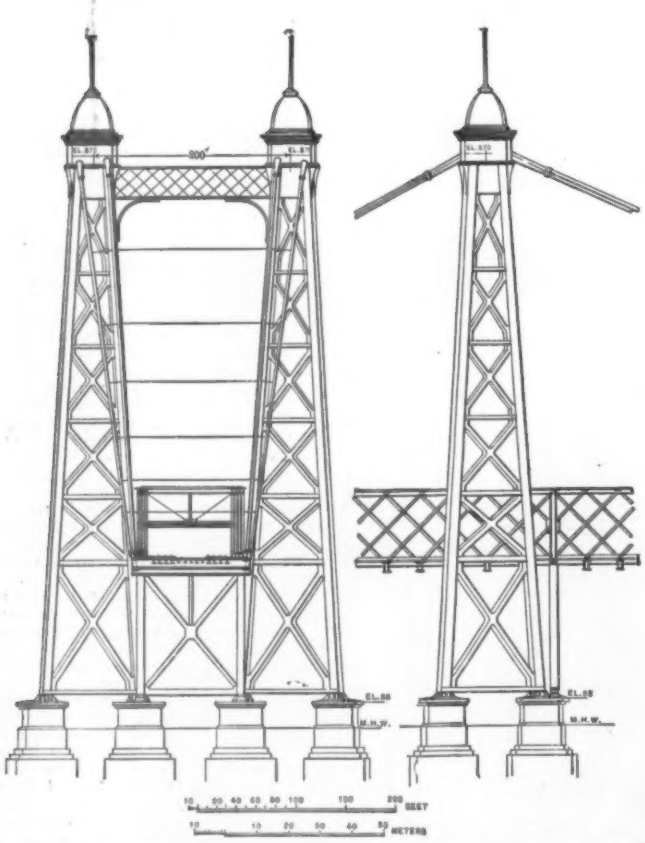


Plate II.—FRONT AND SIDE ELEVATIONS OF TOWERS FOR 3,000 FOOT SUSPENSION BRIDGE.

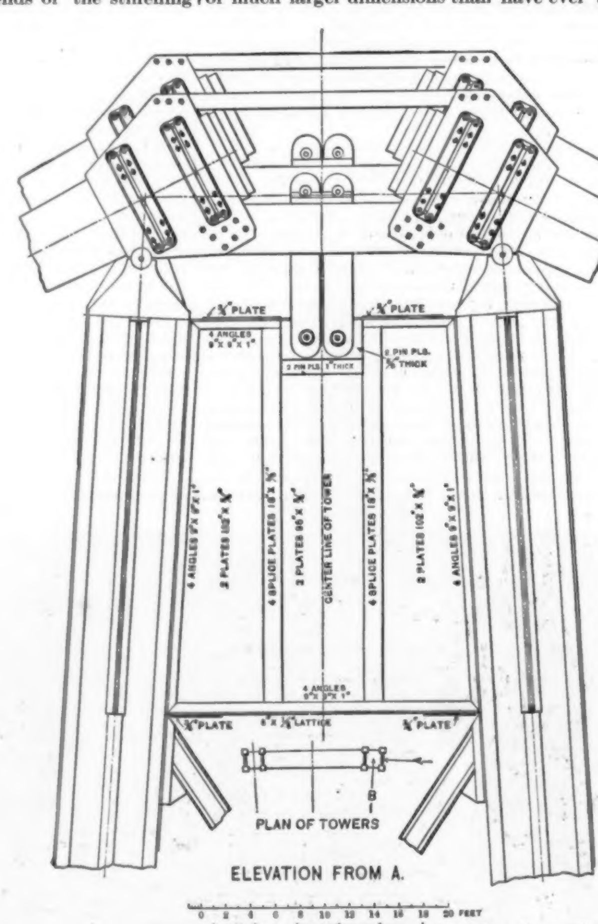


Plate III.—METHOD OF FASTENING CABLES AND BACKSTAYS AT THE TOP OF TOWERS—3,000 FOOT SUSPENSION BRIDGE.

nections being made through the sockets. This modification is really the essential feature of the whole design. The objections which will be raised to it are, first, that a straight wire is both stronger and less extensible than a twisted rope made of the same wire; and second, that no socket can be made which will develop the full strength of the rope. Both of these objections are true, but a rope can be laid in such a way that the modulus of elasticity is only about 1,000,000 lb. less than that of a straight wire, and a rope can be socketed in a way which can be absolutely depended upon to a fixed amount of strain, and the strength of the structure will then be determined, not by the strength of the wire, but the strength of the connection at the end of each rope. Furthermore, experiments have shown that ropes constructed in the manner proposed have an extremely uniform modulus of elasticity, which is the most important thing. The advantages of this system of construction are principally two; the ropes can be made in the shop, adjusted to length there, carried to the bridge site and put up in the least possible time; the wires are practically straight from one end to the other, the decided turns required over saddles and the short turns required around pins being entirely avoided. With this arrangement the objections to a strong stiff wire are removed.

Another feature which is believed to be novel is the method of holding down the ends of the stiffening truss. When one-half the span is loaded, the upward reaction at the unloaded end is equal to the downward reaction at the loaded end, so that the stiffening truss must not only be supported but anchored down. The stiffening truss of this design is made 1,000 feet longer than the span, thus extending 500 ft. back toward the shore from each tower, while the suspenders in the 150 ft. next to each tower are omitted. The result is that the duties of the stiffening truss proper are confined to a length of 2,800 ft.; back of each tower is a span of 500 ft., from which a cantilever 150 ft. long projects to each end of the stiffening truss proper. The reactions of the stiffening truss are taken by the ends of the cantilevers, and the cantilevers are themselves anchored by the weight of the shore spans. This arrangement has the further advantage of leaving 150 ft. between the towers and end suspenders, within which the cables will adapt themselves to any changes of length and height due to temperature, loads or otherwise.

GENERAL DESIGN.

The general design is that of a stiffened suspension bridge, the cables to be of wire, the towers of steel on masonry foundations, the structure being stiffened by steel trusses suspended from the cables.

The cables are four in number, two on each side, the length of span between the theoretical intersection points on the top of the towers being 3,200 ft. and the versed sine 400 ft. To secure lateral stability, the two stiffening trusses are placed 100 ft. between centers horizontally, this affording an opening 92 ft. wide in the clear. At the middle of the span the two cables on each side are brought as close together as possible, or 4 ft. between centers, the width at the center of the span between points midway between the two cable centers being 115 ft. At the top of the towers the cables are spread apart to a distance of 28 ft., the width between the centers of the towers being 200 ft. Each inside cable has, therefore, a cradling of 30·5 ft. and each outer cable a cradling of 54·5 ft., the average cradling between 42·5 ft. The backstays are carried from the towers to the anchorages in planes which are tangent to the horizontal projection of the cradled cables, thus splaying the backstays apart between towers and anchorage. By this arrangement the towers are relieved of all transverse strain, and become, as it were, simply gin poles to sustain the cables. The lateral stability produced by this arrangement is evident from the plan, Fig. 1.

The towers are of steel, each really consisting of two independent towers formed of four posts, 94 ft. square at the base and battered together so as to be 28 ft. square on the top, the two square towers being connected by a cross truss at the top and resting on masonry cylinders at the bottom. The exact shape and location of the half towers are determined by the direction of the cables, the sides of the two half towers not being parallel and the squares being only approximate.

It has been considered important to reduce the number of cables to four, two on each side. If the cables of the main span and the backstays are counted as separate cables, which the detail hereafter described shows them to be, there are four cables, two leading in each direction, terminating at the top of each tower, the number of cables corresponding to the number of posts, so that the weight from each cable is transferred directly to one of the four posts. This requires cables of much larger dimensions than have ever been used, but there is nothing impracticable in making cables of the required size.

The stiffening truss is 4,100 ft. long over all, divided into panels of 33 ft. 4 in. each, supported for the central 2,800 ft. by suspenders leading from the cables, while the ends are supported on piers 4,100 ft. apart and intermediate supports are taken on rocking bents 3,100 ft. apart. The truss is continuous for its whole length of 4,100 ft., fastened to the cables at the center

* Digest of a paper read before the American Society of Civil Engineers, October 21, 1896.

and free to move longitudinally at each end. It is considered of great importance to use a continuous truss, thus avoiding the difficulties and lost motion of a central hinge. The difficulties of fastening down a stiffening truss are overcome by the end supports, the end of each truss being a 500 ft. span resting on two supports, from which a 150 ft. cantilever projects toward the point where the suspenders begin. The suspended stiffening truss is only 2,800 ft. long and exerts an upward or downward reaction at the end of the 150 ft. cantilever, according to the position of the moving load; the cantilevers are anchored by the weights of the end spans. The stiffening truss is 66 ft. 8 in. deep between the centers of gravity of the chords, this depth being adopted for reasons given hereafter; it at once secures the necessary rigidity and permits sufficient flexibility to allow a considerable portion of the irregular moving load to be taken care of by the change of shape in the cables.

CAPACITY.

The bridge has been proportioned to carry a total load of 50,000 lb. per lineal foot, which is equivalent to a stress of 40,000,000 lb. on each of the four cables at the center of the span. The actual dead weight of the cables and suspended superstructure is about 39,000 lb. per lineal foot, thus leaving 11,000 lb. for moving load.

The width in the clear between trusses is 92 ft., which will provide for two double track railroads, each occupying 26 ft., with a space 40 ft. wide between. This 40 ft. can be occupied in various ways; its width is the same as the width between the curbs of Broadway at Twenty-sixth Street; it could be used for four rapid transit tracks either for street cars or for rolling stock of the same dimensions as that used on the elevated railroads; it could be used as a street with two sidewalks and a roadway between wide enough for four carriages to pass; it could be used for two standard gage railroad tracks, with a broad promenade for foot passengers between, or it could be used as a driveway with a street railroad track on each side. Another possible arrangement is the construction of eight parallel railroad tracks 11 ft. between centers, which is admissible on perfectly straight lines, but it is not important to decide how this bridge would be used. Enough has been said to show the capacity which would be afforded, and the weights for which it should be designed.

CABLES.

The cables are the fundamental feature of the design, and will therefore be described first. The design of the cables departs radically from the features hitherto followed in suspension bridges, and provides a method of constructing suspension bridge cables, under which it is possible to do nearly all the work in the shops, and to diminish field work to minimum.

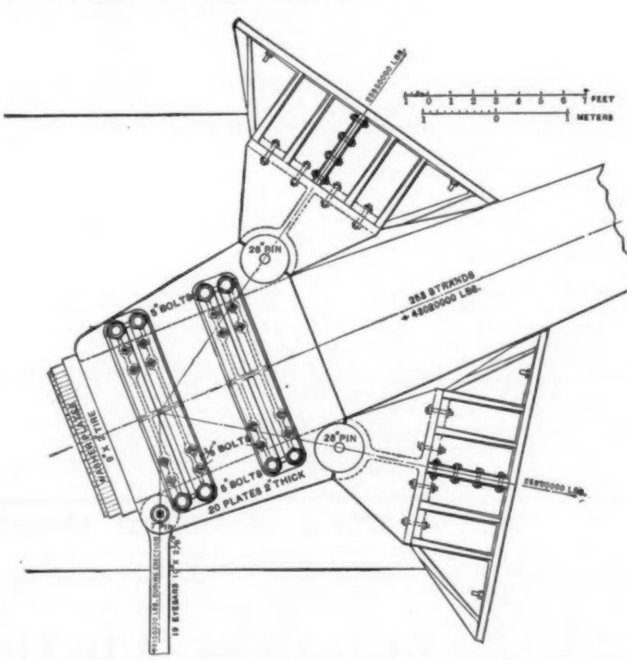


PLATE IV.—METHOD OF FASTENING BACKSTAYS AT ANCHORAGES.

Each cable is composed of 253 ropes of equal size arranged in the form of a hexagon with three ropes omitted from each corner; the maximum stress on each rope will therefore be 76,764 lb. In the design, the ropes are made 2¼ in. diameter, each rope being assumed to have a section equivalent to 3 sq. in. of solid metal and to weigh 10 lb. per lineal foot. The stress per square inch on these ropes will, therefore, be 58,921 lb., of which $\frac{39}{50}$, or 45,958 lb., will be caused by dead load, and $\frac{11}{50}$, or 12,963 lb., by moving load.

Each rope will be a specially laid rope formed of a single straight wire at the center, around which are grouped successive layers of helicoidal wires, so inclined that all will be of the same length, the alternate layers being inclined in opposite directions. When put under strain all wires are equally strained, except the single central wire, which acts as a core. This rope bears no resemblance to the ordinary twisted rope. If not larger than No. 8, the wires of each rope can be made continuous from end to end without splicing.

The method of fastening the cables is shown in Plate III. Fifty feet from each end the several ropes, which are compressed compactly together in the body of the cable, begin to separate so that they are 4·9 in. between centers at the ends, and the successive vertical sets of ropes are 4¼ in. between centers. On the top of each tower post is placed a steel casting through which all vertical strains are transmitted, and on this casting rests a 20 in. steel pin. On this pin are set up 20 steel plates 2 in. thick, each plate measuring 10 ft. in the direction of the axis of the cable and weighing 9,255 lb. The several ropes of which the main cable is composed, when spread, pass between these several plates, being held in exact position by cheap cast iron fillers between the ropes. These plates are machined to a true plane surface on the upper edges, and on these are placed a series of washer plates on which the sockets at the ends of the cables bear. These washer plates are 2¼ in. thick by 16 in. deep, and the divisions come in line with the centers of the ropes. Each washer plate is bored out for its whole depth on each side with half holes slightly larger than the diameter of the ropes, and for a depth of 10 in. with half holes of the diameter of the sockets. Each rope therefore passes through a round hole, one-half of which is bored in each adjacent washer plate and the socket fits into an enlargement of this round hole, bearing on the annular surfaces between the large and small cylinders. The series of washer plates are bound together by a steel tire shrunk around them. The large plates are bolted together with eight 5 in. bolts and sixteen smaller bolts inclined so as to pass between the ropes, all of these bolts screwing up against heavy cast steel washers on the outside, the plates being kept at proper distances by cast iron fillers.

The entire strain in the cables is transmitted to the large steel plates through the washer plates which bear against them. In the large plates this strain is decomposed into a nearly vertical strain which passes through the 20 in. pin and the steel casting into the post, and a horizontal strain which is taken across the top of the tower to the corresponding backstay connection. For convenience of construction and erection this horizontal strain is divided between two tension members, the lower one consisting of nineteen bars each 48 × 2¼ in. and the upper of the same number of bars each 15 × 2¼ in., the strain being transmitted to the former by nine 5 in. pins and to the latter by three 5 in. pins. The full details of this arrangement appear in Fig. 2.

The backstays are of the same dimensions as the main cables and connected at the top of the towers in precisely the same way, the plates to which the backstays are attached being tied to those to which the main cables are attached. In order to keep the cradled cables of precisely the same length, the outer bearings on top of the tower are lower than the inner bearings.

Though the backstays are of the same dimensions as the main cables, they carry no weight but themselves and run in approximately straight lines (being deflected from absolutely straight lines by their own weight) to and through the anchorages, each anchorage having two tunnels in it through which the backstays run.

At the lower end the ropes of the backstays are spread between plates in the same manner as at the top of tower, though the details are different because of the direction in which the strains must be transferred. These details are shown in Plate IV. The strain in the cable is divided into two equal strains, on lines making equal angles with the axis of the cable, and transferred through 26 in. pins to steel castings which bear on closely cut granite masonry, which is built into the coarser material of the anchorage.

When the cables are completed, the clamps which carry the suspenders will be put on. The form of clamp proposed is shown in Plate V, and is quite unlike that commonly used in suspension bridges. The clamp is formed of two steel plates pressed into shape and bound together by eight steel bolts; the lower half is a perfectly plain steel plate, but the upper half has two auxiliary plates riveted on, to hold the saddles which carry the suspenders. By means of cast iron fillers the irregularities in the cables are filled out, and the whole is then surrounded by a sheet of thin metal about 6 in. longer than the clamp plates, this thin metal being simply for protection against weather. The clamp plates are then put on and screwed up tight so that the full friction which can be produced by the bolts is obtained. Two bent saddles of soft metal are then placed on top of the clamp and everything is in readiness to attach the suspenders.

It is thought best not to wrap cables of this size, made of independent ropes, with soft wire as is usually done, but to cover them with a thin layer of some non-conducting substance, which will allow the heat from the sun's rays to reach the metal of the cables no faster than it will be dissipated through the whole volume of the cable.

The arrangement of the suspenders is shown in Plate V. They are wire ropes of the same character and dimensions that are used in the main cables. The detail selected provides for four suspending ropes at each clamp. Each rope would therefore have to carry 81,458 lb., equivalent to 27,153 lb. per square inch, or less than half the stress allowed in the main cables.

There are really but two ropes used at each point, each rope being twice the length of the suspender and fitted at each end into a long socket on which a screw is cut. Each rope passes over the saddle and so forms two suspending ropes; the long sockets pass through washer plates under the floor beams and are adjusted by nuts under these washers, a detail which might be modified in construction. The suspenders are clamped together about 36 ft. below the cables, so as to prevent unnecessary vibration, and where it can conveniently be done the cables will be connected with the stiffening trusses.

TOWERS.

The towers naturally follow the cables in studying the design. The support of the cables at each end of the main span consists of two towers, which form a double tower. Each tower is of approximately square section, with four corner posts, each battering one in sixteen in both directions.

In designing these towers the special functions which they have to perform must be considered. The arrangement by which the cables are attached to the top of the towers holds the towers absolutely, there being no movable saddles. Any change of length in the backstays must be taken up by a change in the position of the top of the tower. These movements at the top of the tower, combined with changes in length in the main cables, regulate the position of the suspended superstructure. It is important that the towers should be comparatively slender, so that they can bend without overstraining the metal. As the top of the tower is anchored by the backstays, a broad base is not necessary for stability.

The actual motion in the top of the tower after the completion of work, due to changes in the length of the backstay caused by a maximum moving load, on the basis of a modulus of elasticity of 26,000,000, will be 6⅞ in., which corresponds to a stress of 2,176 lb. per square inch in the posts of the tower.

The section of each post varies from 1,051 sq. in. at the top to 1,145 sq. in. at the bottom. Each post is 8 ft. square. At intervals of 24 ft. diaphragms would be built in each post, thus coming opposite one of the joints, the function of these diaphragms being the same

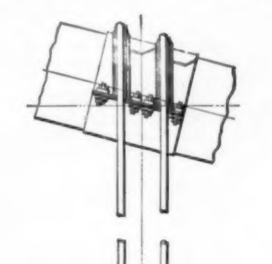
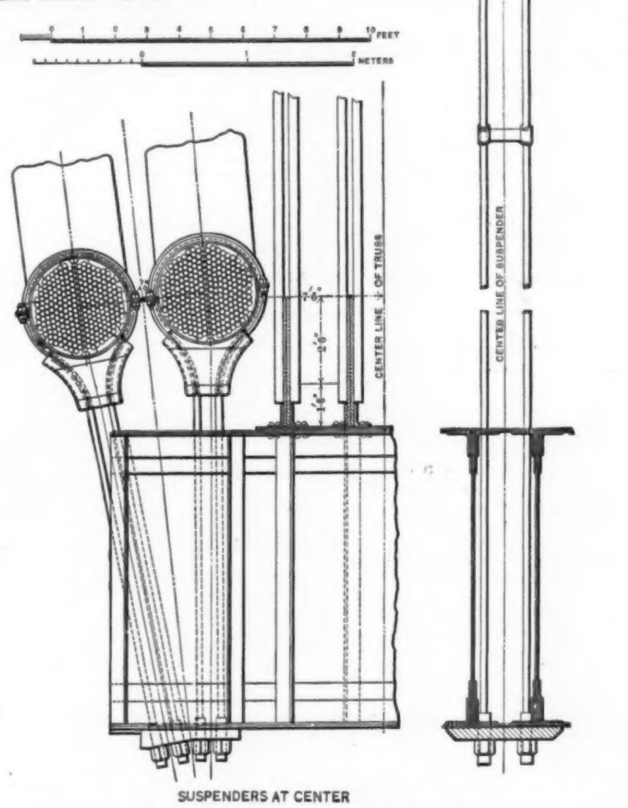



PLATE V.—METHOD OF ATTACHING SUSPENDERS TO CABLES AND FLOOR BEAMS.

as that of the diaphragms in a bamboo rod. At the top two extra cross webs would be built into the post to support the steel casting.

At the bottom the post would rest on a large casting. For convenience of inspection, a hole is made through the middle of each diaphragm, and a series of ladders would reach from diaphragm to diaphragm, by which inspectors could pass through the whole interior of the post, a manhole being placed near the base, through which they could enter. At the bottom each post would be held down by an anchor bolt at each corner, though this is hardly a necessary provision.

At the top the four posts are connected by girders 31 ft. deep, there being two girders on each longitudinal side and one on each transverse side.

The tower is braced on each side between the four posts, this bracing being divided into six panels, the second panel from the bottom corresponding in height to the depth of the stiffening truss, this arrangement being adopted so that the wind strains can be thrown from the stiffening truss into the tower at the panel points of the bracing.

FOUNDATIONS.

The average depth from mean high water to rock at the site of each tower is assumed to be 140 ft. In order to prevent any possible disturbance from expansion and contraction of transverse members at the feet of the metallic towers, it is thought best to rest each post on an entirely independent foundation. There would, therefore, be four independent foundations under each tower, or eight on each side of the river, making sixteen in all. Of these the two center ones next to the river, on each side, would have to support the reaction of the stiffening truss as well as the weight of the tower post, and they are therefore made larger than the others.

ANCHORAGES.

The anchorages at each end of the bridge would be divided into two parts, each of which anchors two cables, the position of these anchorages being shown in Plate I.

The anchorage has no duty to perform except to provide weight, and may be built of a very cheap class of masonry or of concrete. Any class of work which is entirely free from voids and weighs at least 140 lb. per cubic foot, or 3,780 lb. per cubic yard, will answer this purpose.

There will be two tunnels running through each anchorage, each of which should be lined with brick, and be large enough for convenient inspection of cables, and perhaps, also, for running a carrier during erection. At the lower end of each cable there will be a room in which the detail connection is placed, and it will probably be expedient to have some kind of a staircase placed in a small shaft by which these two rooms can be reached. The bearing of the castings must be taken on granite masonry of very high quality, the pressure on the bottom of the castings being 1,000 lb. per square inch, and enough of this masonry has been provided to reduce the pressure on the cheap masonry to 250 lb. per square inch.

Each anchorage would consist of a single block of masonry. It is 180 ft. long, 130 ft. wide, and the top finishes at elevation 155, this being the elevation of the rails.

SUSPENDED SUPERSTRUCTURE.

The suspended superstructure embraces the floor beams and the stiffening truss, with all the necessary cross bracing, laterals, etc. The stiffening truss is the principal feature of the whole, and its peculiar function is such that the calculation of the exact strains is a work of extreme difficulty.

A stiffening truss with a hinge at the center has the advantage of greater simplicity in the calculations, but the details of the hinge are much more objectionable than any irregularities of strain which might occur, and a continuous stiffening truss without a hinge has been used in this design.

The functions of a stiffening truss may be considered in two ways. It may be regarded simply as a floor stiffener, preventing short local changes; or it may be considered as a complete stiffening truss which distributes the entire moving load with practical uniformity over the whole length of the structure. The former is the usual function performed by the stiffening truss of a long span highway bridge; the latter is the function which a stiffening truss must perform in a short span bridge or in a railroad bridge of moderate length.

In the present case the dead load is so great in proportion to the moving load that the distortion of the cables will be comparatively small, even under the passage of trains; it will, however, be so great that if the stiffening truss performed no other functions than that of a floor stiffener, the deflection might disturb the rapid passage of trains.

The condition of loading which will cause the greatest deflection in the loaded portion of the stiffening truss will occur when the maximum moving load covers one-half of the 2,800 suspended feet of stiffening truss, occupying 1,400 ft. on either side of the center; this is also the case in which all calculations are most simple. A limit of deflection of one four-hundredth of the half span, or 3½ ft. in 1,400 ft., corresponds to a 1 per cent. grade at each extreme end of the deflection, and has been selected as the limit in this case.

The moving load which the cables are capable of carrying is equivalent to 11,000 lb. per lineal foot over the entire structure, and it is assumed that this load is distributed over the equivalent of six railroad tracks, corresponding to 1,833 lb. per foot of track. In estimating the effects of an unequal load a weight of 12,000 lb. per lineal foot is taken in accordance with the provisions stated at the beginning of this paper. While it may be considered that the load per foot on one-half or one-third of a span ought to be more than 10 per cent. greater than the load per foot on the whole span, it must be remembered that the peculiar conditions of this bridge are such that it is only under very rare conditions that any considerable portion of the moving load must be distributed by the stiffening truss. In fact, two passenger trains could cross this bridge side by side without disturbing the position of the cables beyond the limits of deflection which are permissible; it is only when the load exceeds that of two maximum passenger trains that the stiffening truss has any duties to perform beyond that of a floor stiffener.

The excess load required to produce a distortion of 3·5 ft. at the quarter on a 2,800 ft. span with a versed sine of 310 ft. (which corresponds to the design) will be 9·424 per cent. of the load on the unloaded portion. Taking the dead load at 39,000 lb. per lineal foot, 9·424 per cent. of this is 3,675 lb.; deducting this from 12,000 lb., there remains 8,325 lb. as the weight per foot to be distributed by the stiffening trusses, or 4,162 lb. for each truss.

The two stiffening trusses designed are each 66·67 ft. deep between centers of gravity, or 70 ft. over all. They are placed 100 ft. between centers. There is a stiff riveted lateral bracing between the top chords and a transverse bracing at every panel point. The floor system is entirely below the bottom chord and the bottom laterals are built in as a portion of this floor system. The webs are riveted lattices with four independent lines of bracing.

The suspended portion of the truss is carried by the floor beams, and as its weight exceeds the amount of moving load which has to be distributed, its action really amounts to varying the portion of its own weight which is transferred to the floor beams, there never being any conditions under which any portion of the weight of the floor system has to be transferred to the stiffening truss. Beyond the limits of the suspenders the floor beams are hung from the stiffening truss, to which they transfer the weight of the floor system.

The floor beams are strong enough to carry the whole weight from truss to truss, thus leaving a clear space for the whole distance. The two double track railroads are placed next to the trusses, thus reducing the weight of the floor beams to a minimum, while the possible deflection of one end of the beam below the other is found not to be enough to produce trouble.

There will be eight railroad stringers in each panel and eight lighter stringers which carry the roadway or the rapid transit tracks.

WIND PRESSURE.

The wind surface per lineal foot presented by one-half of one web, the lower chord and the floor system is 11·35 sq. ft., and the wind surface presented by the upper half of the web and the upper chord is 7·77 sq. ft. As the trusses are 100 ft. apart, the area of the trusses should be doubled, but the floor comes so near to being solid that it need not be doubled. The total surface presented to the wind which must be resisted by the top laterals is therefore 15·54 sq. ft. per lineal foot, and the total surface presented to the wind which must be resisted by the bottom laterals 19·12 sq. ft. per lineal foot. To the latter should be added the area of a passing train, which is equivalent to 8 ft. above the bottom chord, thus making the total wind surface to be provided for 27·12 sq. ft. per lineal foot. On a basis of 30 lb. per square foot the total wind pressure to be resisted is:

Top lateral system	466 lb.
Bottom lateral system	814 "
Total	1,280 "

For the calculations, these figures have been slightly varied, and the top laterals are proportioned to resist a wind pressure of 500 lb. per lineal foot and the bottom laterals a wind pressure of 750 lb. per lineal foot.

There is no probability that anything like these wind strains will ever be reached over the whole length of the span, though considerably greater pressures may occur for limited lengths. To reduce these amounts, however, would be a departure from established practice.

The wind pressure would be transferred to the towers where the stiffening truss passes the towers, by horizontal cables, these cables reaching from each chord to the outer posts of the towers, the cables clearing the inner posts and being long enough to provide for the longitudinal motion of the trusses without overstraining. These horizontal cables would be tightened under strain so that they would always stiffen the trusses. A portion of the wind strain would undoubtedly be taken by the transverse bracing of the rocking bent.

There is also another element which materially reduces the effect of wind. To produce the above-mentioned strains in the chords, the whole suspended superstructure must move laterally 8·75 ft. This involves swinging the main cradled cables and raising the center of gravity of the suspended superstructure, a lateral movement of 8·75 ft. corresponding to a lift of 0·075 ft. or 1 vertical to 117 horizontal. As the suspended superstructure weighs 27,000 lb. per lineal foot, this will require a horizontal force of 230 lb., so that before this deflection can occur the actual wind pressure must be about 1,000 lb. per lineal foot on the bottom chord.

ESTIMATE.

The work has been described in the manner in which the design has taken shape, and the cost of each separate portion has been estimated in connection with this description. In execution the work would necessarily be differently divided and may properly be grouped under the respective heads of substructure and superstructure.

Under these heads the cost may be stated as follows:

Tower foundations	$5,456,000	
Anchorages	2,642,800	
Shore piers	753,600	
Substructure		$8,852,400
Metallic steel towers	$1,912,000	
Wire work, etc.	4,866,149	
Suspended superstructure, etc.	4,492,800	
Superstructure		11,270,949
Total		$20,123,349

For purposes of inspection an elevator ought to be placed in each of the four towers, and two of these elevators ought to be of sufficient size to accommodate passengers; $100,000 should be reserved for these elevators and the various appliances in connection with them.

The ornamental work on top of the towers, with provisions for lighting, etc., would cost another $100,000.

The structure, with a 10 per cent. allowance for contingencies and engineering, would cost about $22,500,000, or somewhat less than $5,500 a foot for the 4,100 ft. of suspended superstructure.

By making some modifications in the plan, among which may be mentioned allowing a greater flexibility under extreme conditions and reducing the depth of the stiffening truss, the cost could probably be reduced to about $20,000,000.

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